Engineering Library

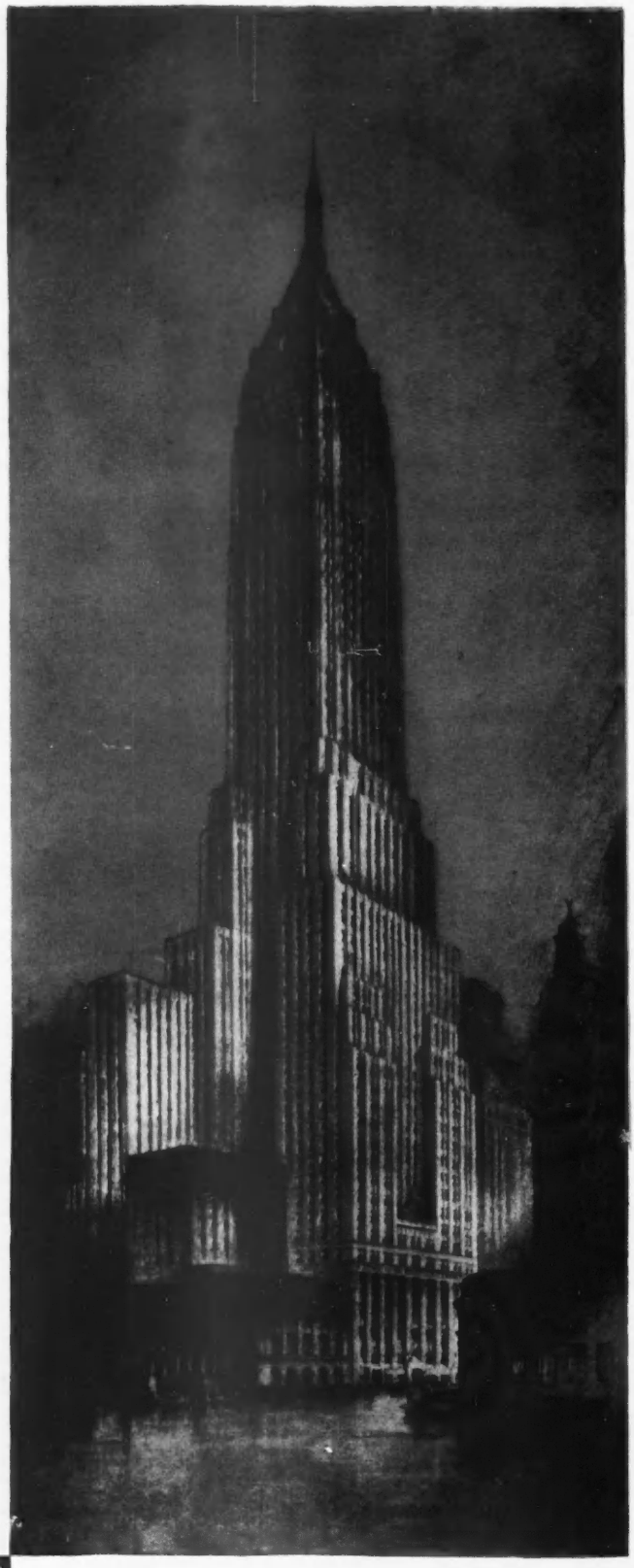
A McGRAW-HILL PUBLICATION

April 24, 1930

APR 26 1930

Engineering News-Record

JEAN RODOLPHE PERRONET—A GREAT FRENCH BRIDGE BUILDER



BANK of MANHATTAN BUILDING

New York City

Framework of Bethlehem Wide-Flange Structural Shapes

BETHLEHEM
STEEL COMPANY

General Offices: Bethlehem, Pa.

District Offices: New York, Boston, Philadelphia, Baltimore, Washington, Atlanta, Buffalo, Pittsburgh, Cleveland, Cincinnati, Detroit, Chicago, St. Louis.

Pacific Coast Distributor: Pacific Coast Steel Corporation, San Francisco, Los Angeles, Seattle, Portland, Honolulu.

Export Distributor: Bethlehem Steel Export Corporation, 25 Broadway, New York City.

BETHLEHEM

ENGINEERING NEWS-RECORD

A Consolidation of Engineering News, Engineering Record, The Sanitary Engineer, and The Contractor

F. E. SCHMITT, *Editor*

Editorial Staff New York
V. T. BOUGHTON, *Managing Editor*
M. N. BAKER
C. S. HILL
W. G. BOWMAN
H. W. RICHARDSON
B. B. GARREABRANT

Editorial Staff Chicago
W. W. DE BERARD
E. E. R. TRATMAN

San Francisco
N. A. BOWERS
J. I. BALLARD

WILLARD CHEVALIER, *Publishing Director*

Contents for April 24, 1930

VOLUME 104, NUMBER 17

Copyright, 1930, by McGraw-Hill Publishing Company, Inc.

French Pioneers in Engineering 676
By JAMES K. FINCH

Harmful Practices in Flame-Cutting of Steel 684

Rational Design of Asphaltic-Oil Roads 686
By H. G. NEVITT

Railroad Tunnel Refloored Under Traffic 689

Unusual Foundation Procedure for Tall Building 691
By W. T. McINTOSH

Text of Decision in Chicago Lake Diversion Case 696

Bridge Cranes Erect London Exhibition Building 697

Editorial 673 Job and Office 698 Letters 700

News 701 Equipment 707 Unit Prices 709

McGRAW-HILL PUBLISHING COMPANY, INC., Tenth Ave. at 36th St., NEW YORK, N. Y.

JAMES H. MCGRAW, Chairman of the Board
MALCOLM MUIR, President
JAMES H. MCGRAW, JR., Vice-Pres. and Treas.
EDWARD J. MEHREN, Vice-President
MASON BRITTON, Vice-President
EDGAR KOBAK, Vice-President
HAROLD W. MCGRAW, Vice-President
H. C. PARMELEE, Editorial Director
C. H. THOMPSON, Secretary

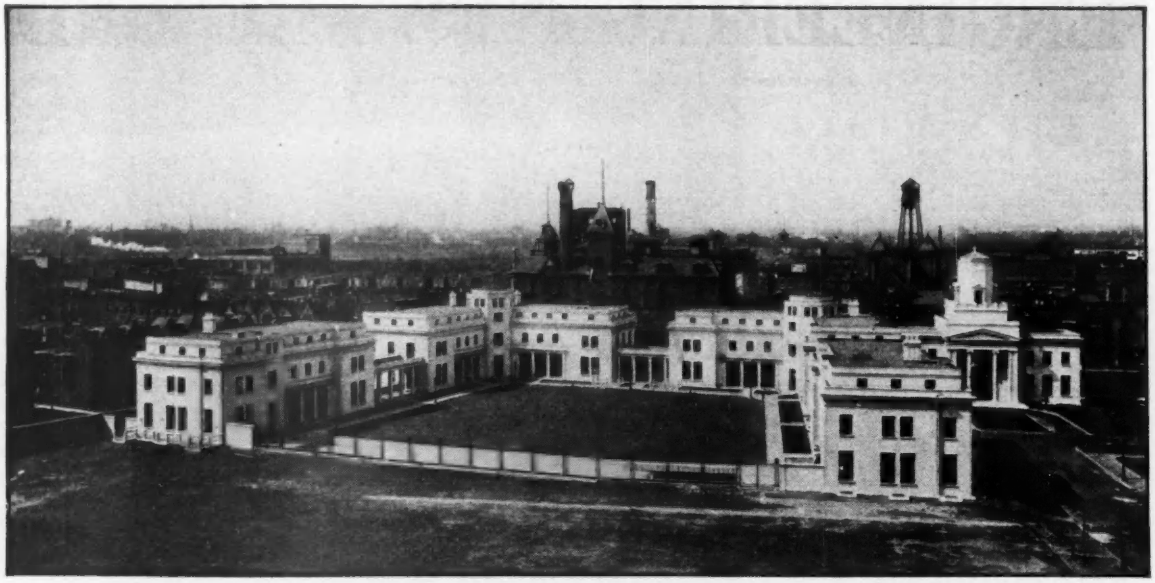
CABLE ADDRESS: "MACHINIST, N. Y."

Published weekly. $5 per year. 25 cents per copy. Entered as second-class matter April 11, 1917, at the Post Office at New York, N. Y., under the Act of March 3, 1879. Printed in U. S. A.

Member A.B.C.
Member A.B.P.

NUMBER OF COPIES PRINTED THIS ISSUE, 32,068

NEW YORK District Office, 285 Madison Avenue
WASHINGTON, National Press Building
CHICAGO, 520 N. Michigan Avenue
PHILADELPHIA, 1600 Arch Street
CLEVELAND, Guardian Building
ST. LOUIS, Bell Telephone Building
SAN FRANCISCO, 883 Mission Street
BOSTON, 1427 Statler Building
GREENVILLE, S. C., 1301 Woodside Building
DETROIT, 2-257 General Motors Building
LOS ANGELES, 632 Chamber of Commerce Bldg.
LONDON, 6 Bouverie Street, London, E. C. 4



GIRARD COLLEGE, Cottage Group, John T. Windrim, *Architect*

Construction Work for Institutions

. . . . . Schools, Colleges, Hospitals, Penitentiaries

UNITED ENGINEERS & CONSTRUCTORS, INC

combining

Dwight P. Robinson & Co., Inc.
Day & Zimmermann Engineering & Construction Co.
The U. G. I. Contracting Co.
Public Service Production Co.
United Engineers & Constructors (Canada) Ltd.
Dwight P. Robinson & Company of Argentina, Inc.
Dwight P. Robinson & Company of Brazil, Inc.

Design and Construct
INDUSTRIAL PLANTS
STEAM POWER STATIONS
HYDRO-ELECTRIC DEVELOPMENTS
RAILROAD WORK
GAS PLANTS

Build
APARTMENTS
HOTELS
OFFICE AND INSTITUTIONAL BUILDINGS

OUR general construction activities include institutional work of almost every character—hospitals, clinic buildings, nurses' homes, dormitories, recitation halls, penitentiaries, power plants—all built in close cooperation with the architect.

Under our form of contract the work is done quickly and at low cost, workmanship of high quality is assured and the interests of trustees and officials are safeguarded.

Among the institutions which we have served as builders have been the following:

Abington Memorial Hospital, Abington, Pa.
Chestnut Hill Hospital, Chestnut Hill, Pa.
Children's Hospital, Philadelphia
Drexel Institute, Philadelphia
Eastern State Penitentiary, Graterford, Pa.
First Presbyterian Church, Pottsville, Pa.
Girard College, Philadelphia
Medical Arts Building, New York
Professional Building, New York
Protestant Episcopal Hospital, Philadelphia
Rockefeller Foundation, Rio de Janeiro
St. Mark's Hospital, New York
University of Pennsylvania Philadelphia

UNITED ENGINEERS & CONSTRUCTORS
INCORPORATED
DWIGHT P. ROBINSON, PRESIDENT

PHILADELPHIA NEW YORK NEWARK CHICAGO
LOS ANGELES MONTREAL BUENOS AIRES RIO DE JANEIRO

MAXIMUM RETURN TO CLIENTS PER DOLLAR INVESTED

ENGINEERING NEWS-RECORD

A McGRAW-HILL PUBLICATION — ESTABLISHED 1874

DEVOTED TO CIVIL ENGINEERING AND CONTRACTING

F. E. SCHMITT, *Editor*

Volume 104 NEW YORK, APRIL 24, 1930 Number 17

Engineering Pioneers

IN THAT slow evolution which developed the art of civil engineering construction as we know it today from the scientific elements of physical mechanics and material study, generations of engineering pioneers figured with notable influence. There were periods marked by the genius of individuals, or of an entire school of men, when methods and procedures were created whose full development could come only much later. Great works were built even though mechanical power was not available and the resources of industry were slight; the blacksmith's forge had to serve in place of the steel mill, and hand shovel and wheelbarrow in place of dragline and motor truck. It is useful to think back to those times as demonstrations of the power of resourcefulness and invention coupled with that intuitive knowledge of materials which is born in the workshop itself. Such opportunity was afforded by the sketch of England's classic days of civil engineering, published in our pages a year ago. It is again afforded by the story of French engineering, a story inspired by the former one. The modern engineer needs such knowledge of his forerunners. He lives under the influence of the history of the engineers of all times, for it is their heritage that makes his work of today effective.

Construction and the Census

IN ANSWERING the questionnaires which have been sent to them by the Bureau of the Census, contractors have the opportunity to develop the statistics which their business so greatly needs to justify the claims it is urging before the public and the legislatures. Few lines of business have as little quantitative knowledge of their activities. In recent years the bureaus of the Department of Commerce have afforded some figures on building work; the Bureau of Public Roads has collected figures on roadbuilding. But for the most part construction statistics have been available only through the agency of the engineering and contracting journals. In view of their origin, partly in reported data and partly in intelligent extrapolation, these figures have been astonishingly accurate in respect to total volume and value of business and its geographical distribution. It has been possible also to break them down with some accuracy into general classes of construction. There has been no possibility of setting up definite facts of the divisions of contracting, number of employees, amounts of payrolls, overhead and equipment expenditures, financing costs, classification of work in detail, and values, volumes and kinds of material consumed. The census survey is undertaken to provide the facts. Its questionnaires have been worked out in co-operation with the Associated General Contractors and ask no more information than it is believed the construction industry should have in order to analyze its power and weakness and plan its future business practices. Frank and full answers by contractors are in order. The results will for the first time furnish a means for appraising the contracting business in detail.

Short Shrift

DISCHARGE without previous warning and without explanation has just been visited on another engineer in municipal work—J. W. Ackerman, city manager of Watertown, N. Y. The right of the council to hire and fire the city manager is one of the fundamentals of the council-manager form of government, but under the standard form of council-manager charter the manager is given notice of the cause of his dismissal and a public hearing before a dismissal becomes effective. Where by mischance there is no such provision in the charter, common decency to the manager and due respect to public opinion dictate a hearing on charges. All the circumstances attending Mr. Ackerman's discharge (glossed over as a request to resign by May 1) indicate politics of the baser sort rather than the undoubted right of the council to change managers—assuming that it has good and sufficient reasons for so doing. Denial by the council majority of a plea for postponement and public hearing, even when urged by the mayor and by citizens outside the rail, as also refusal to give any specific reason for the dismissal, supports this view of the proceedings. It is to be hoped that the citizens of Watertown will continue to protest against the arbitrary action of the council, which must discourage engineers and other competent men from assuming city managerships.

Alexander Dam Failure

NEWS of failure of the Alexander dam in Hawaii does more than merely add to the list of misfortunes attendant upon hydraulic-fill construction. It has a broader interest, because the dam was being built with the aid of a remarkable expedient based on the behavior of colloidal materials—namely, chemical treatment of soil by alkaline salt to flocculate the dispersed soil particles in the puddle trench and promote compaction of the soft material. Its success seemed destined to establish chemical soil treatment as a new and powerful instrument in the civil engineer's armory. The failure of the dam may have the unfortunate effect of surrounding the method with uncertainty and suspicion, even though the accident did not involve the treated earth. From the meager descriptions of the Alexander dam construction work so far received it appears that treatment was applied only to the earth filling of the puddle trench on either side of the cutoff wall below original ground level. This, however, was not connected with the failure if, as the brief news account indicates, the dam was destroyed

by an outbursting of unconsolidated mud from the core of the embankment above ground. Fuller details of the accident will therefore be awaited with unusual interest. If treated material was not involved in the disastrous happening, the chemical method should claim as full attention and interest as before.

Tunnel Explosions

THE electric flashlight or torch, long considered safe around tunnel explosives, was the cause of a premature explosion in the Boston water tunnel, fortunately harmless. It is now suspected also as the cause of an explosion last fall in this same tunnel that cost five lives. The facts are given in a letter published elsewhere in this issue. One particular type of flashlight was found capable of producing a short circuit sufficient to detonate an electric blasting cap when the exploder wires came in contact with the case of the flashlight. This wholly unsuspected source of premature explosions may have caused other mystifying tunnel accidents in the past in which all evidence was usually destroyed and often the entire heading crew was annihilated. Every contractor engaged in tunnel work should, for the safety of his workmen, check up on all flashlights used on the job to determine if lights of this dangerous type are being used. Fully insulated flashlights are available, and in view of the experience in the Boston tunnel no other type should be permitted where electric detonators are involved.

Penalizing Efficiency

FEES paid structural engineers in the building field, and to some extent those paid to the architect, are calculated in such a manner that a penalty is exacted for any savings effected for the owner. This anomalous situation results from the fact that structural steel designers are paid on a tonnage basis and architects' fees are based on a percentage of the contract price. The owner expects the architect to pare the contract price to the minimum, overlooking the fact that he is asking him also to cut his fee. The architect in turn wants the most efficient structural design commensurate with safety. As a result, efficiency and penury have much too close a relationship in the life of a structural designer. With the current trend toward increasing unit stresses and thereby decreasing tonnage, his fees shrink even more. Some of the new building codes also increase the amount of necessary design work, so that the structural designer has become one of the luckless victims of progress. The building owner is entitled to part of the saving that results from the increased unit stresses, but he should hardly expect to receive the full amount saved by using seven-eighths of a ton of steel in place of every full ton that was required under the older building codes. Penalizing efficiency is unsound.

Rational Road Design

THE application of rational methods in designing surface-mixed bituminous roads, as described in this issue, indicates a striving for technical control which engineers generally associate only with the higher types of hard paving. In considering the notable résumé by H. G. Nevitt of rational formulas now employed and the argument for a more comprehensive formula, it is important to note that the highest type of surface-mixed bituminous construction is discussed primarily. This construction involves a graded surfacing metal—crushed stone or gravel—placed new on the cleaned grade and there impregnated and mixed. With inferior types, as where the material on the road (usually with some additions of new material) is treated, or where the material is sand only, rational design becomes less applicable. This does not imply that profitable use of the poorer aggregates is not possible, but that with better materials and better grading superior construction is assured. The roads on which surface-mixed bituminous construction has had its greatest use and perhaps shown its greatest usefulness are those where the materials in place or available in local gravel pits have been utilized. Getting back to the main question of rational design formulas, it is interesting to note how their development and use have centered in the states west of the Rocky Mountains. In the Mississippi Valley and Southern states, where surface-mixed bituminous roads are being constructed in probably greater mileages, the procedure is confessedly in large measure empirical. Comparison is impracticable, since there are too many variables to permit of isolating the influence of rational design formulas, but both practices are producing serviceable, inexpensive road surfaces inferior only to premixed bituminous surfaces and well-constructed penetration macadams.

Steel Embrittlement by Heating

ALL the intricacies and uncertainties which becloud the subject of brittleness in steel are brought to the fore by the studies made in the Columbia University laboratories of a number of cracked and broken wind-brace connections. The particular question at issue is whether ordinary soft structural steel is embrittled by the intense local heating which accompanies oxygen-torch cutting or welding of steel, when done after cold-working (such as punching). The question is of much importance to structural practice. It is to be regretted that the studies do not give a satisfying answer.

As to the particular brackets which broke, the report gives no test data and therefore furnishes no evidence that the brackets were brittle. Further, it does not give assurance that they were of good material (some of them were "seamy" or piped), or that they had not been cracked in handling, as by being bent during shipment of the columns to which they are shop-riveted. As to the merits or demerits of flame-cutting, the report does not show that flame-cutting after punching adds to the damage done by the punching; nor does it show that flame-cutting is more injurious than shearing. Further, it does not show that flame-cutting after punching causes grain growth, a well-known means of embrittlement. It gives no basis for conclusions as to the influence of piping and segregation, or as to the desirability of using a very ductile low-strength steel in preference to a stronger and harder steel when flame-cutting or welding must be done.

The report does show that cold-working hardens the steel, a fact long known. On the question of the effect of heating it contains conflicting evidence: Reduced bending resistance was shown in both static and impact tests of certain laboratory-made brackets flame-cut after punching, as compared with sawed brackets, but on the other hand notched-bar impact tests of small specimens from similar brackets gave no evidence of embrittlement from heating. In reference to the first-mentioned result, moreover, it should be noted that it conflicts with prior tests of the same kind, as reported by J. H. Edwards in our issue of Nov. 1, 1928, p. 666.

Only a brief abstract of the investigation is given in the present issue. The structural engineer will find it profitable to study the entire report with care, in view of the importance of the subject to both riveted and welded steel practice. This is the more necessary because the investigator's far-reaching conclusions cast definite discredit on flame-cutting (and inferentially on welding), though his data are incapable of supporting such conclusions.

The question presented still remains to be explored, therefore. In the meantime practical use of flame-cut I-beam wind connections in the framework of high buildings has continued, and all experience with them in shop and field tends to support existing practice. But since even the suspicion of embrittlement is too serious to be ignored, especially in its bearing on structural welding, the matter should be put under thorough investigation.

Better Lumbering Aids Construction

LUMBERING, a major industry of the Pacific Northwest, is today showing the versatility that is a heritage of the true pioneer spirit. In that territory lumbering now faces economic problems of much the same sort as those confronting other major industries throughout the country; modern trade conditions have made the development of new methods and the refinement of details essential to success. The old order changeth: where a sawmill served by an old-fashioned "logging outfit" could have made profits heretofore, now the production and marketing of lumber have become so highly complex, involving manufacturing processes of an advanced order, that a profit is out of the question. The successful large-scale operator now gives attention to conservation of the timber supply, to the manufacture of various wood products and to co-operation with trade associations for classification and standardization. He also finds the development of new markets to be of the greatest importance. Moreover, there must be proper consideration of technological matters—for example, engineering work in establishing classification for grading and in making stress determinations; also, chemical research on combating decay and in prescribing surface treatment.

The rapidity with which the value of stumpage in the Pacific Northwest has increased in recent years has placed a premium on the development of byproducts and on the reduction of waste. Transportation costs, too, have shown a sharp upward trend. As the more accessible stands have been cut, the cost of getting out logs has steadily increased. Wood products and byproducts of the lumber industry offer ready opportunity for developing new fields and new markets. A demand already has been developed for such wood products as veneer, plywood, shooks and the wide variety of millwork that can be turned out with the higher grades of lumber. Many byproducts are now under investigation or are already on the market in the form of fuel, pulp, sawdust combinations and chemicals. Pulpwood is still a byproduct in the Northwest—that is, trees are not cut there expressly for that market. Curing processes recently have been developed whereby the high moisture content of green lumber can be reduced in a relatively short time to whatever moisture content is best suited to the use intended, and there has been rapidly extending use of woods treated with a preservative—these are some of the opportunities for development that are being studied by the progressive lumber "manufacturer."

It will be observed that most of these fields for development and means of increasing markets are refinements rather than expansion, in the sense of greater volume. The situation is aptly phrased by a student of the lumber industry who recently advised lumbermen: "Make less lumber. Make it better. But do not sell lumber. Sell results and service. And develop byproducts."

Conservation is increasing steadily in importance. To handle it effectively will require broad vision and unselfishness on the part of leaders of the industry. If this is lacking, legislative bodies may be expected to impose more exacting regulations on logging operations with a view to assuring the future of timber resources. This year reforestation bills have been passed in Oregon and in Idaho and a similar bill was introduced in Washington, though it has not yet passed.

In matters of conservation the United States Forest Service has set a high standard by permitting only sustained yield logging—that is, a rate of cut no greater than will be replaced by natural growth. This policy has done little more than set an example, however, because only 5 to 8 per cent of the gross cut in the Northwest is taken from lands under Forest Service jurisdiction. Lumbermen point to taxation as the chief obstacle in the path of widespread adoption of some form of conservation of timber resources. The new forestry laws in Oregon and Idaho may improve this situation. The larger lumber companies have come to realize that in afforestation and reforestation programs there is, at least, a means of increasing the inventory estimate of timberlands.

Standardization is another need which is being met only through organization. In the construction industry it has been the custom to rate the strength of timbers and lumber from the strength of the weak units. The full strength of the stronger timbers has not been properly utilized and could not be prior to some plan for definite classification and grading. The mutual advantage to the construction industry and to lumber companies in grading structural timber has been recognized by the West Coast Lumbermen's Association, the trade organization representative of the fir district in the Pacific Northwest, with the result that there was published in July a new set of specifications and grading rules. Builders may now buy timbers of specified and guaranteed strength, each individual piece of which has been rated by an expert at the mill and there branded to indicate the grade. Although structural grades so classified call for higher unit prices, the cost to the consumer is often less because smaller sizes can safely be used. Also the use of higher unit stresses gives an incidental reduction of freight, handling costs and wastage.

Although lumbering is one of the oldest industries, its development into the modern manufacturing field has materially changed its set-up. Many phases of activity not important in the old days now are being studied and developed. Research work on various properties of timber, notably its strength for structural purposes, is being pushed vigorously. An up-to-date handbook on structural timber is just off the press. Trade extension movements, national and regional, are striving to sell to the public the advances and improvements in the industry. In short, the modern lumberman is now in the large industry class and the more progressive organizations are finding it to their advantage to adopt the same methods by which other large manufacturing industries are making progress. As an outgrowth the construction industry will have better lumber and knowledge of how to use the lumberman's products more efficiently.

THE PONT DE LA CONCORDE, 1791
A bridge in which the least possible obstruction to flow with a level deck is secured by using extremely flat arches.

French Pioneers in Engineering

Men Who Through the Seventeenth and Eighteenth Centuries Laid the Foundations Upon Which Much of the Civil and Military Engineering of Today Is Laid

By James K. Finch
Renwick Professor of Civil Engineering, Columbia University, New York, N. Y.

IF ONE judges solely from the material available in the English language, he is very apt to assume that the pioneers of modern engineering were the great British engineers whose personalities and works were so interestingly described in an article in *Engineering News-Record* in the issue of Dec. 20, 1928. The profession certainly numbers no greater names than those of the great Scotch and English engineers, Brindley, Smeaton, Rennie, Telford, and the Stephensons and Brunels. Yet these men simply carried on and added to the glory of a profession which was already centuries old when they began their careers. Indeed, engineering and civilization are concurrent and the earliest engineer found his first chance for an enduring expression of his skill in the earliest days of civilized life—in ancient Egypt and Mesopotamia. Progress had been continuous through the centuries, and the great British engineers, although pioneers of engineering in Great Britain, cannot be counted as pioneers of engineering in general, although they did make notable contributions to engineering progress. In fact, engineering in Great Britain was very late in getting under way and it owed far more to earlier and even contemporary works and workers in France than is indicated in the above-mentioned paper.

Through all the seventeenth and eighteenth centuries the leadership in engineering had been held by the French, and the modern engineer of any nationality owes a great debt to the French pioneers. Smiles understood this, for in his "Lives of the British Engineers" he tells how Smeaton, the first to call himself a "civil" engineer, studied French and traveled in France, because he recognized that French engineers were the foremost in the field in his day and era. Smiles also pictures for us young John Rennie, the famous Thames bridge builder, as a student at Edinburgh and a frequenter of Andrew Meikle's millwright shop, studying the four volumes of hydraulic engineering, "Architecture Hydraulique," published by Belidor in Paris in 1737. Those four volumes with the inscription "John Rennie, purchased 18 July, 1780, £2.0.0," are on my desk as I write—a striking reminder of the debt this British pioneer owed to the French worker.

Smiles also describes in detail the frightful condition of British roads late in the eighteenth century. It was said, as late as 1768, that it would cost no more to make the roads navigable than to make them hard! On the other hand, the French road system had been developed on a comprehensive plan, and although we hear much of Telford and McAdam, the father of the modern stone road was a Frenchman, Trésaguet.

Thus, to understand the contribution of British engineers to engineering progress, we must know at what point they began. Similarly, to understand the importance and place of the French contribution to engineering progress, it is necessary to review the foundations on which it, in turn, was built.

Beginnings of Modern Engineering

On the collapse of the Western Roman Empire, about 500 A.D., there followed several centuries which have usually been called the Dark Ages—largely, we are now told, because of our ignorance of them. Out of this

JACQUES GABRIEL III (1667-1742)
First chief engineer of the Corps des Ponts et Chaussées.

ADAM DE CRAPONNE (1521-71)
First French canal builder.

RIQUET (1604-80)
Engineer and builder of the first great work of modern times, the Canal du Midi, 1666-81.

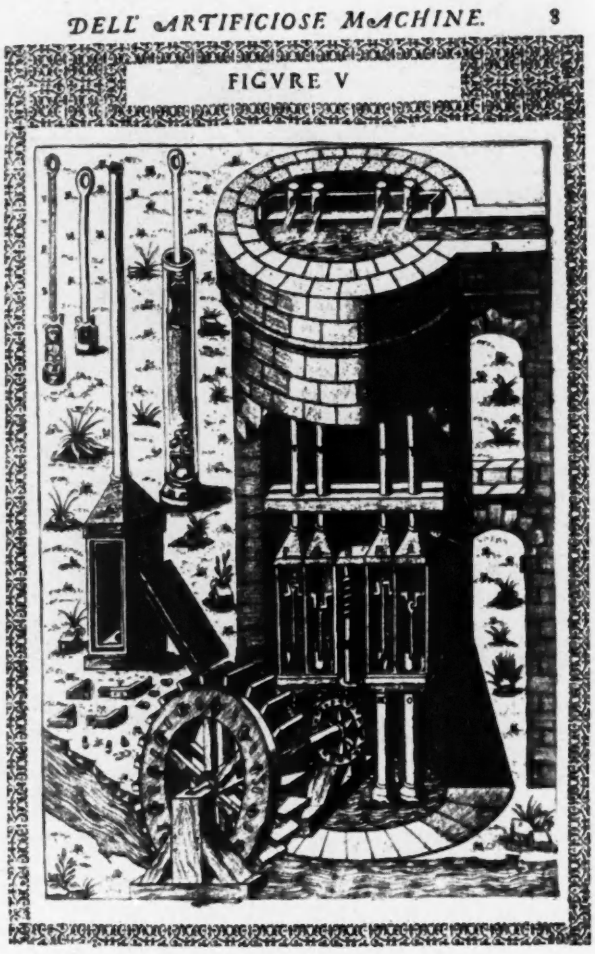
SEBASTIEN LE PRESTRE VAUBAN (1644-1706)
Builder of fortresses and engineer of Dunkirk, whom Voltaire called "first of engineers and best of citizens."

there first came, engineeringly speaking, a widespread revival of bridge building in medieval times which has been attributed in large part to an order of monks, probably largely mythical, known as the Fratres Pontis, or Brothers of the Bridge. (The truth is that the only organized bodies which could or would build bridges were the monastic units of the Church; the "public" hardly existed in this age and the nobility were busy with warlike pastimes.) Many famous bridges of medieval times, generally along the more ancient Roman lines and strongly influenced by if not directly copied from Roman works, still exist scattered over England, France and Italy.

At a later period, the 1100's and 1200's and later, the Gothic development in France blossomed out of this earlier, so-called Romanesque era. The Gothic cathedral was, of course, quite as much a structural triumph as it was an artistic one. Those great "birdcages in stone," which still claim our admiration, also stir up a deep feeling of reverence for the French builders who had the skill and daring to pare down column and arch to such slender proportions, and to balance thrust against thrust, or bring them safe to earth through flying buttresses.

While this was going on in France, the Italian engineers were achieving their great early reputation as the first of modern hydraulic engineers. Canals for irrigation and transport in Italy had no rivals except in the reclamation works of the Dutch. Which of these two nations invented the canal lock is still a debated question, but there is nothing so deep or difficult about the lock as to preclude independent invention in both lands.

While the Gothic period in France lost ground because of the Hundred Years War with England (1328-1453), this Italian development continued and reached its most brilliant phase, the so-called Renaissance, in the late fifteenth and early sixteenth centuries, under the benevolent bosses of the city-states of northern Italy. Here we find the architect-civil engineers, like Palladio, Fontana and others, and the military engineer-architects like Leonardo da Vinci. This period also marks the beginning of the rift between civil engineering and architecture. All through earlier, ancient times there was but one worker, the master builder, or, in Greek, architecton, who was a civil or military engineer or architect as occasion required. It seems probable that gunpowder had much to do with the division which began to be evident in Renaissance times. The architectural fortress-home could no longer withstand attack. New elements, gunpowder and cannon, became of importance, and new technical knowledge and constructions of a non-architec-



A PAGE FROM RAMELLI'S "MACHINERY NOTE BOOK" PUBLISHED AT PARIS IN 1588

THE PONT ROYAL OVER THE SEINE AT PARIS, 1685
In which Romain demonstrated his cofferdam method for pier foundations.

ANTOINE DE CHEZY (1718-98)
Assistant of Perronet and author of the famous hydraulic formula which bears his name.

tural nature, earthworks, were needed for defense. The architect took his name from the ancient Greek architecton; the new engineer from the medieval word, ingeneator, coined from the Latin, as a name for the ingenious man who contrived the many ingenious military devices of the medieval fortresses.

Simultaneously with the later decline of the Italian Renaissance, France entered Italy with the Italian wars, and French kings imported from Italy experts in the new engineering art of earthworks and men also, of course, familiar with canal works. Thus a new era of construction began in France, and it was on the foundation of experience in the building of Gothic times and this inheritance from imported Italian talent that the French engineers rose to a position of engineering leadership. This position they held for almost 300 years—almost to the beginning of the eighteenth century.

The story begins with the Canal of Craponne, the first French canal (1557-61), and ends only with the French Revolution and the growth of an engineering era in Great Britain following the work of Watt with the steam engine (1781) and the Stephensons with the locomotive. These 300 years of undisputed French engineering leadership form one of the main elements in the history of engineering. They cover an era which is both interesting and fascinating and is a most important period of engineering development.

Early French Engineering

Probably the first important French work was the irrigation canal, already mentioned, built by Craponne, a Frenchman of Italian ancestry, which still renders fertile that section of the Crau, east of the mouth of the Rhone, which is known as the Provençal Sahara. Of even greater importance, however, was the Canal of Briare built in 1638. This work, joining the valleys of the Loire and the Seine, was probably the first canal undertaking to cross a summit. Earlier Italian works were more or less river canalizations on one slope. At Briare the engineer first met and solved the problem of a summit water supply. In this same period, that of Louis XIII and Richelieu, Métezeau, "Architecte et Ingenieur du Roi," built the first stone breakwater of modern Europe, thereby assisting, as Dumas tells us, the king, the cardinal, and the "Three Musketeers" in the capture of La Rochelle.

With the age of Louis XIV a golden era of construction was undertaken by this king, who wished to attach his name to the *greatest* works of the ages. Colbert, his able finance minister, persuaded him to assist Riquet, the tax collector turned engineer, who threw himself and his fortune into the first truly great work of modern times—the Canal du Midi. From 1666 to 1681 Riquet worked without let-up in building this canal, 158 miles long with more than 100 locks, across the neck of France just north of Spain, from Bordeaux on the Atlantic to Cette on the Mediterranean. This was a project also involving a summit water supply, and it certainly was as great and daring in its time and age as the Panama Canal has been in ours.

Ask any French schoolboy for the names of the greatest Frenchmen, and he will always include that of Vauban. Even Voltaire, not noted for his compliments, called this great engineer of the reign of Louis XIV "first of engineers and first of citizens," and St. Simon is said to have invented for Vauban the title of "patriot." Vauban has been described as the Builder of Fortresses. He set the lines of the frontier fortresses of France

DUNKIRK, SHOWING THE FAMOUS JETTIES BUILT BY VAUBAN AND THE FORTIFICATIONS

which stood ten years ago during the Great War. He built Dunkirk, fortified it and by means of jetties, the first great work of the kind, confined the current to a narrow section and caused it to scour out a channel for the king's ships. It was the apple of his eye and fortunately he died in 1706 before England had forced the French king to demolish this great triumph of Vauban's genius and skill.

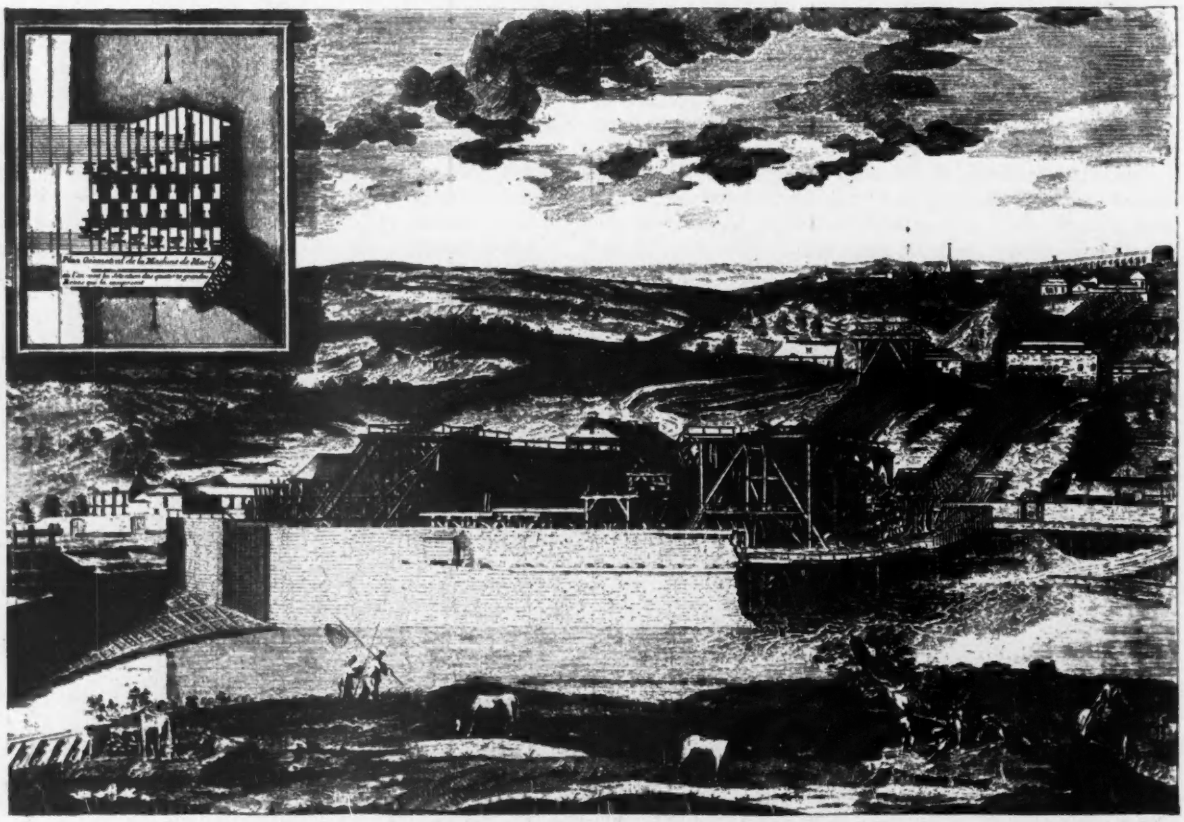
But Vauban did even more for the engineering profession than simply to construct great and pioneer works. He found the engineer attached as an individual to various military commanders, unorganized and having no professional standing as a group. In 1672 he secured the organization of a Corps of Engineers in the French army. This brought a sense of unity, an esprit du corps, among previously scattered engineering workers. He gave to this corps a tradition of service which took no thought of personal gain, which visualized engineering work as a great public service intrusted to the engineer and in which honor was to be achieved only by fidelity to this trust—by an honest, unbiased search for the best solution of a problem which the economic conditions and knowledge of the day permits. His influence on the profession in these early days of its new birth still endures, and the distinctly military viewpoint which is so often exhibited by engineers who give their time and effort unstintingly to public service and to the interests of their clients is but an echo of the tradition of which Vauban's life and work is so notable an example.

The French Bridge Builders

It was also under Louis XIV that the Pont Royal over the Seine at Paris was built. Francois Romain, the Dutch bridge-building monk, was called to Paris in 1685 and introduced new foundation methods in the construction of the piers of this bridge. The highway system of France had been conceived on a comprehensive scale at an earlier day, and the necessity for highway bridges forced a development in design and foundation processes in France which brought the stone arch bridge practically to perfection by the close of the eighteenth century.

In 1716 the famous Corps des Ponts et Chaussées was organized. Its first engineer was Jacques Gabriel, one of a famous family of master builders. His greatest monument is a long arch bridge which crosses the Loire at Blois. Gabriel was followed by the greatest of French bridge builders, Perronet, who solved a problem which had been bothering bridge engineers for centuries.

The old Roman bridges were solid and substantial affairs with massive piers which offered a formidable obstruction to floodflows. Their high, full-centered arches also required steep approaches if the banks of the stream were low. Many of these bridges were practically dams with holes in them for floods to pass through. The problem was to secure the greatest possible waterway, the least obstruction to flow, under a practically level bridge floor and using only stone arch construction. Perronet's most famous work is perhaps the Pont de la Concorde at Paris. It crosses the Seine in five spans and its deck is level with the quay walls on the side. Additional waterway was secured by building extremely flat arches; the rise is only 13 ft. for a span of 102 ft., which also causes a reduction in the vertical component of the thrusts and hence permits high slender piers. The compression in the arch ring is, of course, high, and Perronet used the strong stone of Saillancourt



THE MACHINE OF MARLY

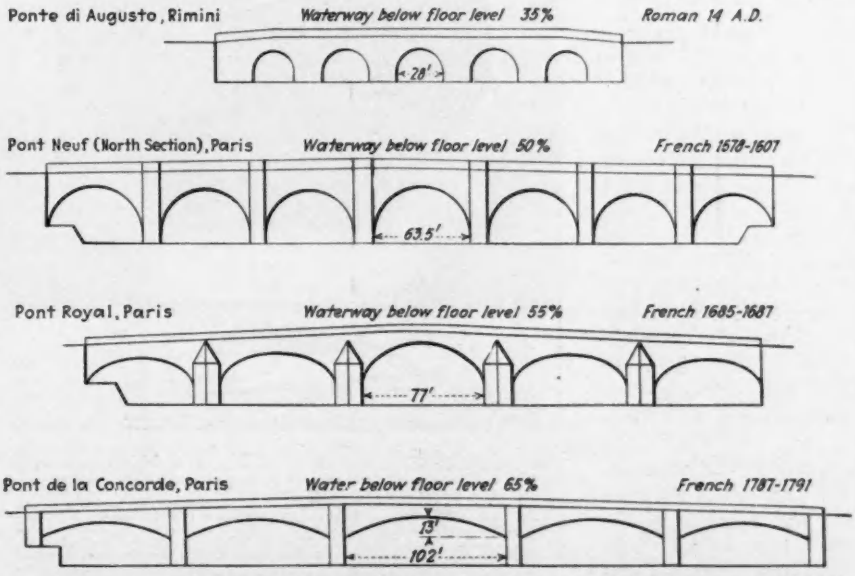
This "forest of iron and wood," with its fourteen waterwheels and its 225 pumps, lifted water from the Seine some 525 ft. for supplying the fountains of Versailles. Probably the greatest machine of the age before steam.

THE CANAL OF BRIARE (1638)
Connecting the Loire and the Seine, probably the first canal to cross a summit.

for this ring, which is very thick and occupies practically the full space between intrados and floor. While the piers have little more to do than support the weight of the bridge, there are naturally high end thrusts which are carried into the solid quay walls. Of the total low-water cross-section of this bridge below the floor, two-thirds is open space under and between arches. Earlier Roman works show as low as 40 or less, and at the best only 50 per cent of waterway.

This was Perronet's last work. It is interesting to picture him, an old man of more than 80 years, sitting in the window of the house which he had secured on the left bank of the Seine overlooking the bridge. His right-hand man, Chézy, author of the famous hydraulic formula which bears his name, was in charge of the construction under the eye of the master. The bridge, the crowning achievement of Perronet's career, was begun under Louis XVI and was to have been named after him. Before it was completed the unfortunate Louis had met the guillotine in the Place de la Concorde at its north end. The work, however, went on. Stones were drawn from the Bastille to finish it, and Perronet, before his death in 1794, had the pleasure of seeing his work complete as it stands today. We should remember that Perronet had no means of computing arch thrusts; his design was a monument of art and of the genius for construction rather than of science. Yet his work was perfect—given only stone to work with, the modern engineer could not improve on Perronet's masterpiece.

In the development of bridge pier foundations we have mentioned Romain and should not neglect Labelye, a Frenchman who was called in to build the Westminster bridge across the Thames at London in 1739. From 1209 to 1823 old London bridge was in service and until 1739 it was the only bridge at London. There being no recognized British bridge builders and the French being acknowledged experts, Labelye was called to London on this work. His pier foundations were on piles, and the piers were built by means of a casse, or caisson, with removable sides. Perronet, on the other hand, generally used a batardeau, or cofferdam, unwatered the site, excavated a few feet and drove piles. Contemporary with this foremost of stone bridge builders were De Voglie and De Cessart, who made history in foundation work. De Voglie designed apparatus for cutting piles off under water, and thus in combination with Labelye's caisson, effected a saving in



PROGRESS IN BRIDGE DESIGN FROM THE FIRST TO THE EIGHTEENTH CENTURY

BERTRAND FOREST DE BELIDOR (1697-1761)
Soldier, engineer, author. His "Architecture Hydraulique," Paris, 1737, marked a new era in hydraulic engineering.

the cost of pier construction. De Cessart used immense floating cones or caissons in building the digue, or breakwater, of Cherbourg. British workers, Cochrane and Brunel, gave engineering the compressed air and shield process and made deep and assured foundations possible, but Romain, Labelye, De Voglie and their co-workers in France were the pioneers of modern foundation practice.

Highway Construction

As we have already noted, highway development in France was begun at an early day. It may be said to have started under Henry IV in 1599, when he appointed Sully "grand voyer de France." The old Roman trails and roads in France, estimated by some to have totaled as high as 12,000 miles, had gone to pieces bit by bit. Sully began their resconstruction. Under Louis XIII, however, progress was retarded, the new service was decentralized, and control was turned back to the treasurers-general. Again, under Louis XIV and due without doubt to the far-seeing vision of his able minister, Colbert (1619-83), Sully's work was revived. After Colbert progress again declined, but in 1705 the national highway system of France was born, and a little later the covée plan of forced labor, which had first appeared during the close of the seventeenth century, was made general.

Two names stand out very distinctly in the organization of the Corps des Ponts et Chaussées which followed these developments: Perronet, the real founder of the corps, and Trudaine, who directed this service from 1748 to 1769. Trudaine was an organizer, Perronet was a bridge builder. The roadbuilder was Trésaguet.

This highway expert built many important works, but his chief claim to fame rests on his report submitted in 1775 to the Assembly of Bridges and Highways. In it he described, for the first time, the construction of the modern stone road. It would seem clear beyond question that Trésaguet rather than Telford should be credited with the invention of what we now know as a telford base. It is, of course, true that the constructions of both Trésaguet and of Telford were later superseded by the far less costly broken-stone base and wearing surface of McAdam. But it is also true that the first step in modernizing ancient Roman road construction into a practical modern form was due to Trésaguet. He may be prôperly called the father of modern highway construction, but his name, unfortunately, is practically unknown and Telford and McAdam receive credit for work in which Trésaguet was the pioneer.

Machinery and Invention

In the field of machinery and instruments French workers also properly claim attention. Ramelli, the soldier-author of Italian origin, published his notebook of machinery, beautifully illustrated with wonderful engravings, at Paris in 1588. Jacques Besson also published a similar work about the same time.

These books are doubtless filled with much which was pure invention and was never put to practical test and use; nevertheless, some of the many plans were certainly

CLEMENT METEZEAU
Builder of the first stone breakwater of modern Europe.

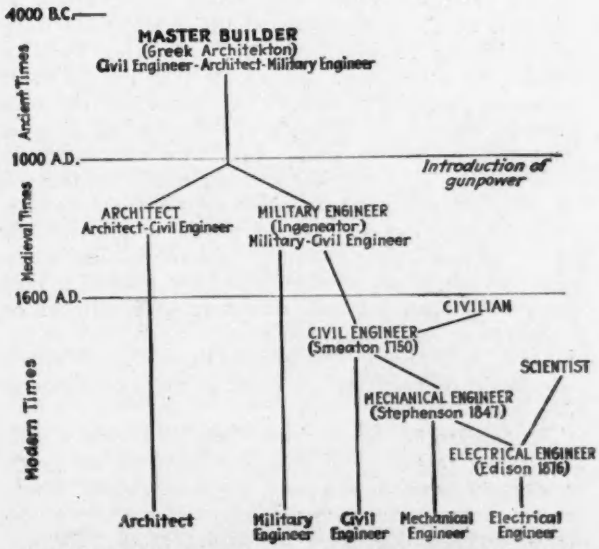
executed. Pumps, for example, for elevating water from streams to public fountains in the towns were much in demand. La Samarataine (1612) was a famous Paris waterwheel pump of the variety Ramelli describes, and other pumps were used for pumping water from the Seine as late as 1830. Greatest of all these machines, however, was that wonderful "forest of iron and wood," the Machine of Marly, built to supply water for the gardens of Louis XIV at Versailles in 1686.

In surveying there comes to mind the names of Pierre Vernier, the inventor of a device still used on every engineer's transit and on many other instruments; of Abbé Picard, the father of geodetic surveying, and of many other workers who were called in to run levels for proposed water-supply systems for Versailles and other works of the king. Picard, Romer, De la Hire and others devised leveling instruments with telescopic sights for their work. The level bubble was known at the time, but was not much thought of; hence other ingenious means of securing a horizontal line of sight were used.

Hydraulics

In the hydraulic field there have been many notable French workers. The name of Henri Pitot (1695-1771) undoubtedly stands out as that of one of the pioneers. Pitot got into a great fight with the theorists of his day when he questioned the elaborate but erroneous theories of velocity distribution and streamflow which they had evolved. In order that velocity might actually be measured, he invented the Pitot tube in 1732. From this beginning data were gradually secured, and in 1785 Chézy, whom we have already noted as Perronet's right-hand man, proposed the remarkable generalization expressed in the formula still known by his name, $V = C\sqrt{RS}$.

After this, attention centered on the value of C, and the work of the great modern French hydraulic expert Bazin was a notable contribution toward the solution of this and other important hydraulic problems. In 1856 another famous French worker whose name is known to all hydraulic engineers, Darcy (1803-58), published his work on the water supply of his native city of Dijon, a work of great importance in the development of the knowledge of flow in pipes.



ORIGIN OF THE VARIOUS BRANCHES OF ENGINEERING
Chart showing their relation to and growth from the ancient profession of master builder.

JEAN RODOLPHE PERRONET
Greatest of French bridge builders and first director of the Ecole des Ponts et Chaussées.

These, however, were later workers, and it has been our purpose to note more particularly the earlier pioneers of French engineering. It might reasonably be asked why engineering in France suffered an eclipse with the advent of the nineteenth century. The answer, we believe, is to be found not only in the fact that the founders of the new era of mechanical power, Watt and Stephenson, were British, not French, subjects, and in the economic difficulties through which France passed after the Revolution and Napoleonic wars, but also in a change in emphasis in French engineering work. The Academy of Sciences at Paris, founded by Colbert in 1666, had been securing a stronger and stronger grip on French engineering matters, and by 1800 or 1810 science had the upper hand in the Ecole de Ponts et Chaussées as well as in the Corps. Coulomb, De Prony and their confreres made notable and valuable contributions to the mathematical theories of structures and machines which were later co-ordinated and expanded by the great Scotch teacher Rankine in his "Applied Mechanics" of 1858. These studies were essential to the changes which were gradually taking place in engineering technique—it was changing from an art to a science—but these men were primarily theorists who favored mathematics rather than construction and who found themselves in an environment that afforded little encouragement to construction. Theory grew apace, but actual construction was at a standstill. Great Britain and America forged ahead, while France built only a few canals; it was not until the age of Napoleon III that modern engineering in France made any real progress. Thus engineering leadership passed from France to Great Britain and later took a long journey across the Atlantic to America. We should remember, however, that British engineering was founded on the truly remarkable achievements of the French workers of the seventeenth century and that the modern mathematical and rational methods of design were born in France, even if they were developed and extended by workers in other lands. Surely these were sufficiently great contributions to engineering progress to justify our nomination of these great men of France for the Engineering Hall of Fame.

Practices in Flame-Cutting of Steel Reported Harmful

Tests Show Evidence of Brittleness in Windbracing Brackets Flame-Cut After Punching—Remedies Suggested

DURING the erection of the new Consolidated Gas Building in New York City two years ago a number of broken or cracked wind brackets were discovered, and nine of these were submitted to the testing laboratories at Columbia University for study in the hope of determining the cause of failure. Prof. W. J. Krefeld, engineer of tests at the university, has reported the results of this study in a pamphlet, "An Investigation of the Failure of Flame-Cut Windbracing Brackets," Bulletin 3 of the department of civil engineering.

The brackets were T-shaped, formed by flame-cutting 24-in. 120-lb. I-beams along the center lines of the webs. Used as a beam-to-column connection, such a bracket was riveted by its flanges to the column, while its web or stem lapped over the bottom or top flange of the beam and was riveted to it. Usually the brackets were shop-riveted to the columns and field-riveted to the beams. During shipment of the columns they projected in such a way as to be easily bent, and the question of whether the damaged brackets had been injured in shipment was involved.

The investigation included a study of the failed brackets and the manufacture and subsequent testing of other

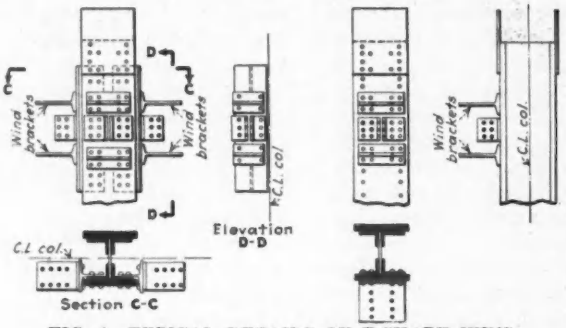


FIG. 1—TYPICAL DETAILS OF T-SHAPE WIND BRACKETS FLAME-CUT FROM I-BEAMS

brackets made from structural steel of the same grade as used in the building. The broken brackets were examined metallographically and the effects of fabrication methods were studied, and strains produced by punching and local heating were surveyed qualitatively. However, the principal studies bearing on the question of whether flame-cutting caused the breaks in the brackets on the Consolidated Gas Building included squeeze tests and Izod impact tests on small specimens cut from I-beams of the same grade of steel used on the job, and drop impact tests and static-bend tests on laboratory-made brackets.

Material and Handling Found Good

Three factors were recognized as possible contributors to the failures—namely, faulty material, abnormal conditions of handling during shipment and erection, and phenomena inherent in the formative processes. As to the first two, tests showed the steel to have normal physical properties, and "the possibility of failure being due to abnormal treatment during handling and shipment is not likely," according to the report. In analyzing the effect of the fabrication process, the report stresses the facts that cold-punching, which represents the first operation in the formation of such brackets, permanently and seriously deforms the material near the rivet hole, and that the subsequent oxyacetylene-cutting operation involves such intense local heating as to produce (1) residual strains in the bracket and (2) grain growth and brittleness.

Small-Specimen Tests for Brittleness

In order to determine the effect upon the impact value of various degrees of permanent deformation, both with and without the subsequent application of heat, specimens

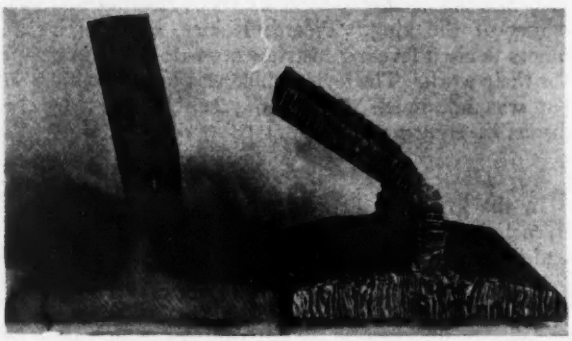


FIG. 2—COLD-SAWED AND FLAME-CUT BRACKETS AFTER SUBJECTION TO A 12-FT. DROP OF A 260-LB. WEIGHT

No cracks were produced in the cold-sawed bracket on the left, while the flame-cut bracket all but severed along the lower line of rivet holes.

were squeezed and later tested in an Izod impact testing machine. Strips 0.6 in. wide were sawed transversely from the web of a beam and milled to ½x½-in. section, 5½ in. long. To produce a plastically strained condition the specimens were subjected to lateral pressure between two ½x½-in. hardened steel bearing blocks placed transversely across the test bar. Pressure was applied for one minute at four sections 1.10 in. apart along the 5½-in. length of the test bar, corresponding to the location of notches which subsequently were provided for the standard Izod impact test specimen. The amount of permanent deformation was measured by the decrease in thickness of the resulting from the indentations made by the bearing blocks. In straining different bars, increasing pressures were applied, so that the series of specimens prepared represented the same material with different degrees of permanent deformation, ranging from zero to 8.5 per cent. Test bars were made in duplicate, one set being intended for tests to determine the effect of this straining alone on the impact value, while the other set was heated for 30 minutes to 250 deg. C. 24 hours after straining; in cooling, these specimens were placed on an asbestos pad and allowed to cool slowly while protected from air currents. Finally, all of the bars were subjected to test in an Izod impact machine of 120 ft.-lb. capacity. The average impact values of the four breaks on each bar are given in the accompanying table.

The conclusions drawn from these tests were: (1) The impact resistance of structural steel of the grade investigated decreases as a result of plastic strain. While the loss is dependent upon the degree of overstrain, the rate of decrease is greatest for small strains. The impact value is reduced to 22 per cent of its original value when the overstrain is 8 per cent. (2) Application of

moderate heat to overstrained steel still further decreases the impact resistance. For the grade of structural steel investigated, this further decrease depended upon the degrees of strain and heat and amounted to 45 per cent of the impact value of the strained but unheated material when deformed 3.25 per cent and subsequently heated to 250 deg. C. The greatest effect appears to be produced on material moderately deformed—that is, about 3.25 per cent. When heated above 300 deg. C., smaller losses in impact value result, until at about 450 or 500 deg. C. no

IMPACT TESTS FOR EFFECT OF VARYING STRAIN

Specimens Strained Only		Specimens Strained and Subsequently Heated to 250 Deg. C.	
Per Cent Deformation	Average Impact Value, Ft.-Lb.	Per Cent Deformation	Average Impact Value, Ft.-Lb.
None	30.75	None	28.6
1.15	21.9	1.15	18.75
1.25	22.75	1.25	15.75
1.72	20.6	1.80	13.9
2.10	18.6	2.15	12.0
2.72	16.5	2.55	9.5
3.20	12.6	3.55	6.9
4.40	10.1	4.30	6.0
5.15	9.0	5.45	5.75
6.80	7.3	6.80	4.3
8.35	6.75	8.42	4.25

NOTE—The per cent deformation and impact values given are the averages of four determinations made upon the same bar. All specimens cut transversely to rolling from web of a 24-in. 120-lb. test beam.

decrease is effected by the subsequent heating. In fact, heating to temperatures slightly above 500 deg. C. will result in a recovery of impact resistance.

Other Specimen Tests—During the progress of the study to determine the effects of plastic strains and heat upon the impact resistance, Rockwell hardness determinations were made upon the specimens prepared. The conclusion was that hardness of steel is increased by overstrain and is still further increased when subsequently heated.

Cold-bending tests of this grade of steel showed brittleness in pieces heated after deformation. Both the original material and pieces deformed by squeezing could be bent flat around a ¾-in. pin, but pieces heated after squeezing failed in the bend, cracking at angles of 95 to 120 deg.

Tests on Brackets

Supplementing the specimen tests, other tests were made upon full-size brackets. One of these tests, a drop impact test, was designed to subject the web to cantilever action. The other was a static-bend test.

Drop Tests—For the drop impact tests, four T's with flanges 12 in. long and webs 8½ in. long were used. Two of the specimens were flame-cut and two were cold-cut with a hacksaw; all specimens had been punched in a multiple punch, so that, except for the method of cutting, the brackets were identical. Each bracket was arranged by a clamping apparatus to simulate its position when riveted to a column, with the web of the bracket outstanding. A cylindrical weight of 260 lb., composed of a section of steel pipe filled with concrete, was suspended by a manila rope directly over the specimen and plumbed so as to strike a 1x1x10-in. steel bar laid along the outer end of the projecting web. Two brackets—one flame-cut and one cold-sawed—were subjected to the falling weight dropping 12 ft., while for the two other brackets the weight was dropped 15 ft.

The cold-sawed specimens in the drop test were bent, and in the 15-ft. drop a short crack was produced. The flame-cut brackets, on the other hand, broke in the test. The author of the report concludes that the drop test "showed a marked difference in the shock-absorbing ability of the two types of brackets. The tests indicated that the flame-cutting operation had decreased the impact values of previously punched brackets approximately 40 per cent."

Static-Bend Tests—As a further comparison between flame-cut and sawed brackets, a static-bend test was performed, in which the web was subjected to flexural cantilever action. The flanges of a cold-sawed and a flame-cut specimen (both cut after punching) were connected by three ¾-in. bolts at the lower edges, 1½-in. spacing blocks being placed between the flanges. This spacing permitted a 1½-in. round bar to be placed between the flanges with ends projecting so as to afford a means of applying the load. Rocker supports for the webs of the brackets were placed 26½ in. apart. The load was applied slowly to the center bearing bar, and "before any great distortion of either bracket web had occurred, two loud snaps in quick succession gave notice of cracks in the web of the flame-cut bracket;" the cold-sawed bracket failed to show any cracks on the surface of the web.

In conclusion, the report states: "The flame-cutting operation has been to a large extent responsible for

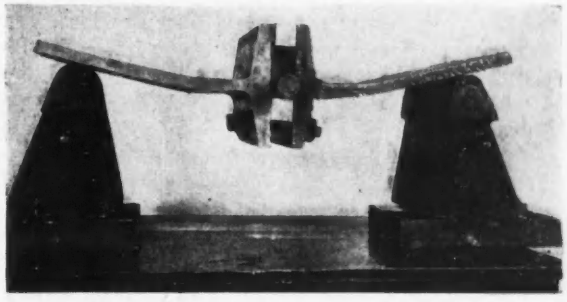


FIG. 3—ASSEMBLY FOR COLD BEND TEST
Flame-cut bracket at right had cracked when picture was taken.

the decreased shock and bending properties of the brackets, and, together with conspiring effects of quality and handling treatment, has contributed largely to the failures." Professor Krefeld makes the following alternative recommendations: That (reversing the usual sequence) beams shall first be flame-cut to size and then punched; or that the brackets shall, after fabrication by multiple punching and flame-cutting, be annealed at a temperature of about 550 deg. C., but not under 450 deg. C. or over 600 deg. C. He believes that the results of his studies warrant the extra cost of such procedure in the interest of safety.

Parking Space Scarce in Business District

A recent survey shows that more than 100,000 motor vehicles enter the central traffic district of San Francisco between 8 a.m. and 6 p.m. each business day and that there is total parking space for only 11,416 of them in the same area. Further study of the parking situation indicated that, taking these 11,416 parking possibilities as 100 per cent, 27 per cent of the total space has special restrictions for loading zones, taxi stands, etc., 20 per cent is curb space with a 40-minute parking limit, 42 per cent is in garages and about 11 per cent is furnished by parking lots. Investigation showed that, as between the two latter types of parking space, the public preferred the parking lot to the garage for short-time storage during the business days and evenings.

Rational Design of Asphaltic-Oil Roads

Review and Appraisal of Previous Formulas and Statement of Improved Formula for Determining the Oil Content for Various Materials in Surface-Mixed Asphaltic-Oil Roads, With Tables and Charts of Values of Factors in Formula

By H. G. Nevitt

Manager, Road Oil and Asphalt Department, White Eagle Oil Corporation, Casper, Wyo.

OIL treatment of roads has differentiated into the surface-treatment method and the surface-mixing method. In surface treatment, oil is applied to an existing compacted road surface, penetrates the upper portion of the road and acts as a binder. A cover material, such as stone chips or sand, is applied to prevent the oil from picking up under traffic. In the surfacing-mixing process the predetermined quantity of oil is actually incorporated with the road metal to give the desired thickness of oiled mat, and the loose metal is bladed or worked until a thorough mixture has taken place, with uniform distribution of oil throughout the aggregate. The mixed material is then distributed to grade and allowed to compact under traffic. This discussion deals with surface-mixed asphaltic-oil roads, the design and construction of which has often been haphazard.

Graded Aggregates Required

In general the aggregates utilized in the surface-mixing method should be proportioned, as nearly as practicable within economic limits, to a balanced grading as shown by Fuller's curve or its equivalent. It is generally agreed that material larger than 1 in. in diameter should be discarded and that an excess of extremely fine material is undesirable. Binder material of high clay content should be avoided, because of the effect of moisture on clay. Typical specifications for cementing qualities in the aggregate call for binder material with a linear shrinkage of not more than 5 per cent, a field moisture equivalent of not more than 20 per cent and a minimum of 100 lb. per square inch compressive strength when formed into a mortar with water.

When the aggregates show a deficiency in material passing the 10-mesh sieve, fines should be added to secure the desired grading. However, as in other types of paving mixtures, the selection and proportioning of aggregates must depend largely upon such factors as availability of local materials, funds available and class of traffic to be carried. Obviously, better graded materials will give longer service, and every effort should be made to secure proper proportioning without materially raising the cost of construction.

Determining the Oil Content

The aggregate having been suitably proportioned, the correct quantity of oil to be incorporated in the mix is next to be determined. Two methods are in general use for judging the correct ratio—by an empirical formula and by the stain test. In the latter a pat stain of the mixture is made on paper, as in testing sheet asphalt, and the percentage of oil is varied until the stain shows the color and texture desired, with the imprint of the individual particles distinct and unblurred. The stain test is essentially a cut-and-try method, and while useful in field control, has the disadvantage of requiring the rather fine discrimination of an experienced observer for the interpretation of results. Many engineers incline to the opinion that other uncontrollable factors enter into the results obtained by the stain test. It is probable that a combination of the two methods will prove most satisfactory—the application of an empirical formula for setting a mix, followed by field control by a comparison of stain tests made in the field with sample stains of the theoretically correct mix as furnished by the laboratory.

Suggested Formulas Reviewed

Several formulas, similar in character but differing widely in the results obtained, have been developed for determining oil content. C. L. McKesson, of the California Highway Department, and W. N. Frickstad, United States Bureau of Public Roads, have advanced one of the first of these formulas, which is expressed as

$$P = 0.015a + 0.03b + 0.17c$$

in which P is the per cent by weight of oil to be added to the aggregate, a is the per cent of aggregate retained on the 10-mesh sieve, b is the per cent passing 10-mesh and retained on the 200-mesh, c is the per cent passing the 200-mesh sieve.

This formula has been in general use for state highway construction in California and Oregon, and has been adapted for use in Utah by increasing by about 25 per cent the percentage of oil indicated and the addition of an absorption factor, with a correction based on relative specific gravity of the oil used. The Utah formula, for an oil of 0.97 gravity, becomes

$$P = 0.02a + 0.033b + 0.195c + H$$

in which H is a factor depending on the absorption of the aggregate, determined by first weighing the aggregate, thoroughly dried at a temperature sufficient to drive off any water, and then weighing after immersion in water for five hours, after which the material is sun-dried until no surface moisture can be observed. The increase in weight gives the index of absorption, and the percentage of oil is increased in direct proportion to the percentage of water absorbed, first allowing 0.5 per cent as normal absorption.

Where an oil of different gravity is used, a conversion factor is introduced in the Utah formula, to secure terms of equal volume. Thus, using an oil of 1.08 gravity, the formula becomes

$$P = (0.02a + 0.033b + 0.195c + H)1.1$$

For Wyoming conditions the California formula indicates much too low a percentage of oil, and the Wyoming State Highway Department has adapted the formula by providing for a 40 per cent increase in oil quantity. The Wyoming formula thus becomes

$$P = (0.015a + 0.03b + 0.17c)1.4$$

The writer has expressed the California formula in a different form, to correspond to the form in which the data are more usually available, as

$$P = 1.5 + 0.14A + 0.015B$$

in which P is the per cent by weight of oil to be added

to the aggregate, A is the total per cent of dry aggregate passing the 200-mesh sieve, and B is the total per cent of dry aggregate passing the 10-mesh sieve.

The modification of the formula used by the Wyoming State Highway Department, expressed in these terms, thus becomes

$$P = 2.1 + 0.20A + 0.021B$$

A formula in use by the highway department of New Mexico expresses these values in slightly different terms as

$$P = 0.02a + 0.07b + 0.15c + 0.20d$$

in which P is the per cent by weight of oil to be added to the aggregate, a is the per cent of aggregate retained on the 48-mesh Tyler sieve, b is the per cent passing 48-mesh and retained on the 100-mesh, c is the per cent passing 100-mesh and retained on the 200-mesh, and d is the per cent passing the 200-mesh sieve.

It is stated that these values were arrived at by ascertaining the amount of oil necessary to give the highest compressive strength for each sieve size of the aggregate, and then combining these results to give the values of a, b, c and d. In each case an amount of oil slightly lower than that giving the peak compressive strength was set as the percentage factor P.

In the 1929 *Bulletin* of the Engineering Experiment Station of the University of Idaho, attention is called to the fact that the percentage of oil developed by the use of the California formula is too low and that values obtained should be modified for Idaho conditions to allow for at least 1 per cent more oil than indicated. In line with this practice a curve has been developed to show the various relations, which in the average case gives much the same results as the modified Wyoming formula when a is taken for the actual analysis of the aggregate but c is taken as 5 per cent, which happens to be about the average encountered. However, the Idaho curve indicates a slightly less percentage of oil than the Wyoming formula for the range of $(b + c) = 17$ per cent to 52 per cent and slightly more outside this range.

TABLE I—COMPARISON OF RESULTS OBTAINED BY FIVE ROAD-OIL FORMULAS

Sample	Total Percentage of Aggregate Passing									
	1 In.	¾ In.	½ In.	10 m.	20 m.	30 m.	40 m.	50 m.	100 m.	200 m.
105	100.0	93.4	76.7	49.5	40.8	34.7	31.5	27.6	18.5	10.1
106	.....	.....	.....	100.0	98.1	93.3	89.2	82.2	55.6	43.8
113	.....	100.0	97.0	79.7	48.5	29.0	21.2	14.4	6.8	3.9

	Oil Percentages Indicated by Various Formulas				
	McK-F.	Utah	Wyoming	Idaho Curve	New Mexico
105	3.657	4.278	5.119	4.8	5.365
106	9.132	10.396	12.785	Unobtainable	12.748
113	3.242	3.667	4.539	Unobtainable	3.459

The Idaho curves have been carefully worked out from actual examination of road samples and are said to give satisfactory results. However, it would seem that these curves are not entirely adequate, since only the particles passing the ¼-in. screen are considered. Likewise, the original McKesson-Frickstad formula would seem to place too much emphasis on the extreme fines and to slight the coarser particles.

It is interesting to note that none except the Utah formula provides for variables such as comparative shape, texture or porosity of the mineral aggregate particles, or for the physical characteristics of the oils. The results obtained by applying these formulas show wide variance and do not reflect the influence of certain factors that enter into actual results.

Table I is a comparison of the values obtained by the five formulas reviewed, assuming the use of aggregates having approximately the composition of tests 105, 106 and 113 in the McKesson-Frickstad report (1927).

In examining road surfaces where these formulas have been used as a basis for proportioning, it is found that in many cases the percentage of oil applied according to the formula has proved to be insufficient, while in others an excess of oil is apparent. It would therefore seem that none of these formulas is universally reliable and that there is a need for a more rational method of design which will reflect all factors encountered and yet will not lack the simplicity necessary for practical requirements.

Improved Formula Developed

Obviously, the composition of the mix, on a weight percentage basis, will be affected by characteristics of the mineral aggregate such as the specific gravity of the aggregate in relation to the specific gravity of the oil, shape, texture, relative surface area, size distribution as shown by screen analysis, absorptive properties, and percentage of voids. The viscosity of the oil at test temperatures and under actual climatic conditions in the oiled mat will further influence results.

TABLE II—VALUES OF THE MATERIAL COEFFICIENT M

Material	Value of M
Quartz or sand, particles uncoated	1.00
Siliceous material, portion of particles coated	1.05
Decomposed granite	1.10
Sand, particles moderately coated	1.15
Feldspar	1.10-1.15
Sand, particles highly coated	1.30
Limestone, average	1.30
Lava and other porous material	1.50 and up

A method has been formulated which is believed to embody the elements affecting the composition of the mix and to combine these factors in a logical and correct manner. The terms of this formula are tentative as regards the values given the different factors, and are subject to revision, but these represent careful study of oiled roads and mat materials over a considerable period of time and under varied conditions. This method has been developed first to offer a better type of formula, and second to outline certain tentative values for the different coefficients, which may be used as a basis for further study. The formula is expressed as

$$P = MWSFD + V$$

in which P is the per cent by weight of oil to be added to the aggregate, M is an absorption coefficient, depending on the materials used in the aggregate, W is a coefficient depending on the relative specific gravity of the dry aggregate and the oil, S is a coefficient depending on the shape and surface texture of the average aggregate particles (predominant consideration being given to those in the 10-mesh range or below), F is a film thickness coefficient, depending on the viscosity of the oil and the average climatic conditions encountered, D represents the size distribution of the aggregate, as determined by screen analysis, and V is a correction based on the percentage of voids in the dry aggregate.

M, the material or absorption coefficient, is determined by the property of the mineral aggregate of absorbing or adsorbing a certain quantity of oil, with a consequent reduction of the bonding power of this oil. On the basis of present data, Table II shows the estimated values for this coefficient. The value of the coefficient for limestone will vary according to the hardness and type of this material, and all values shown will vary more or less according to the properties of material from different localities. Coefficients are given for average conditions,

TABLE III—VALUES OF THE WEIGHT COEFFICIENT *W*

Spr. Gr. of Oil	Specific Gravity of Dry Aggregate							
	2.50	2.55	2.60	2.65	2.70	2.75	2.80	2.85
0.93	1.02	1.00	0.98	0.96	0.94	0.92	0.91	0.89
0.95	1.04	1.02	1.00	0.98	0.96	0.94	0.93	0.91
0.97	1.06	1.04	1.02	1.00	0.98	0.96	0.95	0.93
0.99	1.08	1.06	1.04	1.02	1.00	0.98	0.97	0.95
1.01	1.10	1.08	1.06	1.04	1.02	1.00	0.99	0.97
1.03	1.12	1.10	1.08	1.06	1.04	1.02	1.01	0.99
1.05	1.14	1.12	1.10	1.08	1.06	1.04	1.02	1.00
1.07	1.16	1.14	1.12	1.10	1.08	1.06	1.04	1.02
1.09	1.19	1.16	1.14	1.12	1.10	1.08	1.06	1.04
1.11	1.21	1.18	1.16	1.14	1.12	1.10	1.08	1.06

and for more accurate results values for M must be selected as determined by the characteristics of the aggregate materials available in each locality, either by judging from the appearance of the aggregate or by means of some test for absorption, as for example the previously mentioned absorption test of the Utah highway department.

In Table II, where the material is referred to as coated, the reference is to a deposit on the surface of the aggregate particles of a cementitious coating, of different composition from the aggregate itself. Thus, a hard, non-absorptive sand grain may have a coating of argillaceous, gelatinous or ferruginous nature which may be highly absorptive. In general, material which has undergone considerable erosion, such as river sand, is less likely to show such a coating.

W, the weight coefficient, is proportional to the relation between the specific gravity of the aggregate material and the specific gravity of the oil, and may be taken as unity where the gravity of the aggregate material is 2.65 and the gravity of the oil is 0.97. Other values for W may be read from Table III. To convert the weight of the oil to terms of volume, as determined by the relative specific gravity of the aggregate and the oil, divide the specific gravity of the aggregate by the specific gravity of the oil. For the per cent by volume of the oil to be added to the aggregate, multiply the result by the per cent by weight of the oil.

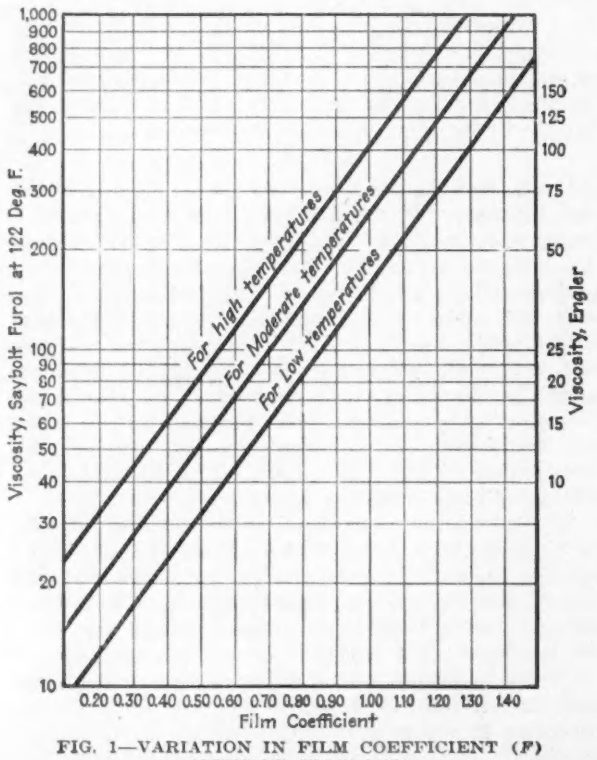

Viscosity, Saybolt Furol at 122 Deg. F.
Viscosity, Engler
For high temperatures
For Moderate temperatures
For Low temperatures
Film Coefficient
0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 1.10 1.20 1.30 1.40

FIG. 1—VARIATION IN FILM COEFFICIENT (*F*) WITH OIL VISCOSITY

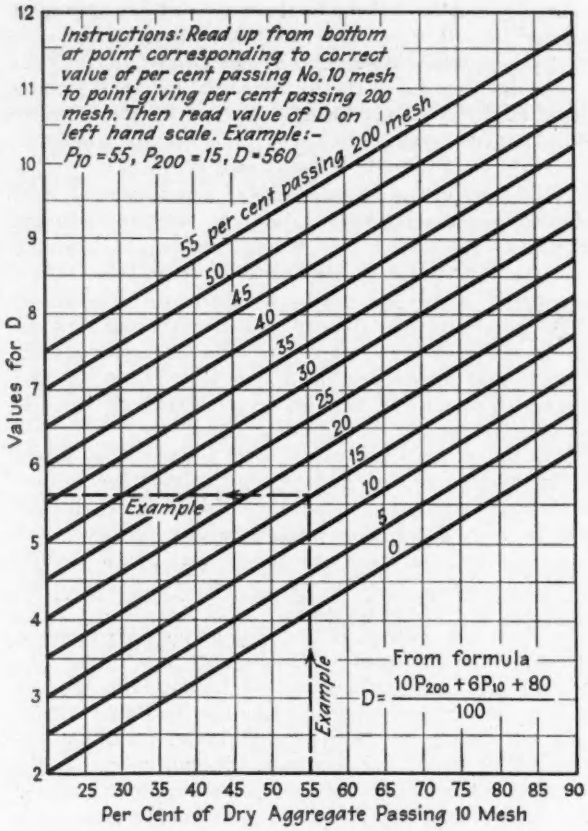

Instructions: Read up from bottom at point corresponding to correct value of per cent passing No. 10 mesh to point giving per cent passing 200 mesh. Then read value of D on left hand scale. Example:- P10 = 55, P200 = 15, D = 560
55 per cent passing 200 mesh
50
45
40
35
30
25
20
15
10
5
0
Example
Example
From formula
D = (10P200 + 6P10 + 80) / 100
Values for D
Per Cent of Dry Aggregate Passing 10 Mesh

FIG. 2—VALUES FOR COEFFICIENT *D* AS INDICATED BY SCREEN ANALYSIS OF AGGREGATE

S, the shape coefficient, depends upon the shape and surface texture of the aggregate particles. The more irregular the shape and the rougher the surface the greater will be the surface area of these particles and the higher the percentage of oil necessary completely to coat the particles. Preliminary suggested values for this coefficient are as follows:

Practically spherical particles with very smooth surfaces	0.75
Almost cubical shape with smooth surfaces	0.85
Fairly cubical shape with smooth surfaces	0.90
Fairly cubical shape with rougher surfaces	0.95
Irregular fracture, angular shape and fairly smooth surfaces	1.00
Irregular fracture, angular shape and irregular surfaces	1.25
Irregular fracture, angular shape and very rough surfaces	1.50

F, the film thickness coefficient, reflects the difference in thickness of oil film required due to variation in the viscosity of the oils in the completed oil mat. This is dependent on two factors: the viscosity of the oil at the standard test temperature, and the actual average climatic conditions encountered by the oil on the road throughout the year. This coefficient may be read from Fig. 1.

D, the aggregate size coefficient, expresses the variation in the size of the aggregate particles, as shown by screen analysis. The smaller aggregate particles have a larger total amount of surface area to be covered by the oil film, but the thickness of the film decreases, almost but not quite offsetting the increase in film area. The resultant effect of these two factors is expressed in the following formula and can be read from Fig. 2:

$$D = (10P_{200} + 6P_{10} + 80) \div 100$$

in which P_{200} is the *total* amount by weight of the dry aggregate passing the 200-mesh sieve and P_{10} is the *total*

amount by weight of the aggregate passing the 10-mesh sieve.

While a factor V, for void correction, appears in the formula, this correction is seldom necessary, except where there is an exceptionally high void content in the aggregate. The percentage of voids in the dry aggregate is computed by some standard method. The weight of the oil to be added to the aggregate is then computed from the first part of the formula, and this weight is converted to percentage by volume by the method given under the discussion of the coefficient W. This oil volume is then subtracted from the percentage of voids in the dry aggregate. If the remaining voids exceed 12 per cent, a volume of oil is added sufficient to fill the voids in excess of 12 per cent. By then reducing this volume to terms of weight, the percentage of additional oil to be added to that already determined by the formula is found. The preceding is of course a rough rule, and judgment may be required in its application to unusual cases showing very high voids.

Example of Computation

As an example of the application of the formula, take an aggregate with 45.5 per cent passing the 10-mesh sieve and 8 per cent passing the 200-mesh sieve. As 60 per cent of this material passed the ¼-in. screen, the Idaho curve calls for an addition of 4.4 per cent of oil. Working out the value of D as equal to $10P_{200} + 6P_{10} + 80 \div 100$, the result is 4.33, which would represent the percentage of oil to be added to the aggregate if the other coefficients were taken as unity. However, an examination of the materials will give values for the other coefficients as follows: The aggregate is a moderately coated sand, with a value for M of 1.15; the specific gravity of the oil is 0.97 and the gravity of the aggregate 2.65, giving a value of 1 for W; the shape of the particles is "irregular fracture, angular shape, with fairly smooth surfaces," giving a value of 1 for S; the viscosity of the oil is 225 Saybolt-Furol, or approximately 56 Engler, and the average climatic conditions are moderate to cold, which by referring to the chart Fig. 1 gives a value of 1.05 for F.

The formula thus becomes $P = 1.15 \times 1 \times 1.05 \times 4.33$, indicating 5.2 per cent of oil to be added to the aggregate. The dry aggregate shows a void content of 20 per cent. Converting the 5.2 per cent of oil by weight to terms of per cent by volume, we have $2.65 \times 5.2 \div 0.97$, or 14.2 per cent. Since after subtracting 14.2 from 20 per cent the remaining voids are less than 12 per cent, no void correction is necessary and the proper percentage of oil to be added remains at 5.2 per cent.

Conclusion

The tables and charts giving the values of the various coefficients are based upon average experience with the materials available, and some are of course subject to correction and refinement. It is the writer's desire to invite discussion as to possible refinement and as to additional values for other materials. It is thought, however, that the formula advanced is correct in its basic terms and should offer a foundation for the development of more exact theory of design.

Railroad Tunnel Refloored Under Traffic When Walls Settle

Concrete Invert Reconstructed With 12-In. I-Beam Reinforcing Under Double Track Carrying More Than 100 Trains Per Day

TUNNEL No. 4 on the main line of the Southern Pacific Railway leading out of San Francisco to the south has been repaired for the second time to strengthen the invert against heavy ground pressure that caused a serious inward movement of the side walls. This tunnel is a double-track bore about 5 miles from the San Francisco terminal and, in addition to main-line trains, carries heavy local traffic, the total number of trains per day being about 125 when the recent work was done. The method of stopping the movement, as described in the following, consisted of putting heavy I-beams under the rails and embedding them in concrete, this work being done without interrupting the heavy train schedule. A period of about 3½ months was required for completing the work, which was finished in March, 1928.

The tunnel is 3,547 ft. long, was completed in 1907 and is lined with concrete, the side walls being 30 in. thick and the arch having a brick lining inside the concrete. Weepholes were provided in the side walls on 12-ft. centers, and through these the material which the tunnel traverses is believed always to have had adequate vents for drainage so that hydrostatic pressure could not have developed.

The first trouble in this tunnel developed in 1911, when it was discovered that the side walls were beginning to crowd inward, presumably from the thrust of the adjacent rock. Remedial measures, consisting of reinforcing of the invert for 578 ft., were begun at once and resulted in entirely stopping the movement—to date the walls have shown no further movement in the portion of the tunnel whose invert was rebuilt at that time. The wall movement of 1911 involved a maximum settlement of 0.994 ft. and at railhead the original horizontal clearance was reduced by 1.44 ft. Reconstruction was carried out in much the same way as on the later work, described in the following:

Trouble again developed in 1927, when the invert appeared to be heaving the track. On removal of the ballast the concrete below was found to be shattered as if by excessive pressure at two places in the tunnel several hundred feet away from the portion repaired in 1911. At these points the side walls were moving inward, accompanied by vertical settlement, but this time the movement was less than in 1911. In 1927 the maximum vertical settlement of the side walls at the spring line on one side amounted to 0.354 ft. and on the other side to 0.244 ft. At the spring line the horizontal movement reduced the original clearance by 0.51 ft. and at rail height by 0.565 ft. It was this inward movement of the walls that had caused the invert to shatter and heave the tracks.

When the 1927 movement was discovered, in order to check it immediately pending permanent reconstruction of the invert, a temporary bracing system consisting of 12x14-in. timbers was put under the rails extending from wall to wall. These timbers were cut to a length equal to half the tunnel width and a central longitudinal timber was used as a header. The timber-bracing system carried the side thrust while ballast and broken concrete was removed and the new invert put in.

The two stretches of the invert where reconstruction

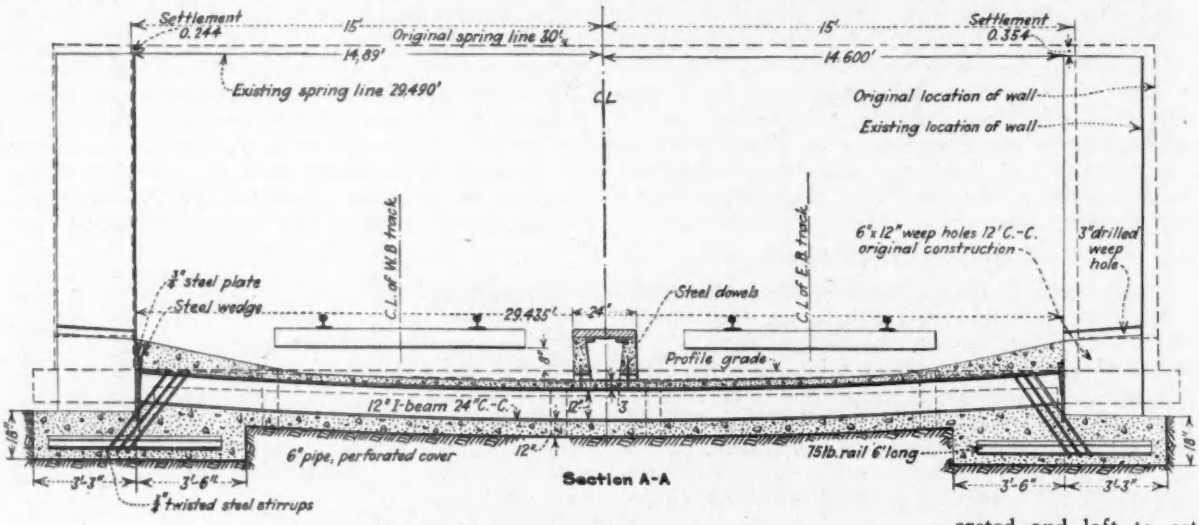
was required were 26 and 52 ft. long, respectively. The work included (1) deeper excavations for enlarged wall foundations to prevent further settling and (2) the placing of 12-in. I-beams about 29 ft. long bent in a vertical curve with a central ordinate of 6 in. to protect the invert from further squeezing in of the side walls. The I-beams extended from wall to wall, being placed against steel bearing plates, against which they were tightened up with wedges.

The wall footings were enlarged to a width of 6 ft. 9 in., and made 1½ ft. deep. Reinforcing in the footings was provided in the form of 6-ft. sections of 75-lb. rails on 2-ft. centers. These were held by stirrups extending from I-beams to rails, as shown in the accompanying drawing, so that when the footings and invert were poured the whole would form a monolith. The concrete invert as reconstructed is 21 in. thick, the I-beams having, at the center, 6 in. of concrete below and 3 in. above.

The outstanding feature of the work was getting the I-beams into place without interrupting traffic. This was done by single-tracking the tunnel from 12:10 a.m. to 5:30 a.m. while the work was under way. During this period only one passenger train was scheduled. The work was carried on in two shifts; the day shift made ready for the night crew and did as much of the work as could be carried on without interference with train operations. The night crew worked under the protection of flagmen at both ends of the tunnel.

When the tunnel was single-tracked after midnight, the track that was out of main line service was used for moving in equipment and materials. Concreting was done with a mixer and materials that had been assembled on flat cars during the day and moved as a train into the tunnel on the idle track as soon as single tracking went into effect. At the point where repairs were under way rails were removed from the idle track as often as was necessary.

Actual placing of the 12-in. I-beams and the concrete around them was done in 2-ft. sections. That is, ballast was removed from an 8-ft. length of the track at a time and the rails were supported on blocks while the old invert was removed. Then a 2-ft. section would be concreted and left to set while work proceeded elsewhere. By constructing in alternate sections the rails always had adequate support.



PLAN AND SECTIONS SHOWING INVERT RECONSTRUCTION

All of the work was done on one side—that is, without interfering with clearances necessary to train movement on the opposite track—so that throughout the repair one track was always open to traffic.

In connection with the reconstruction the tunnel was reballasted. There was also some rearrangement of the drainage system, which now consists of a concrete center drain the full length of the tunnel and concrete gutters at either side, which also extend for the full length except in those sections where the inverts have been reconstructed. In these sections where the heavier invert has been put in the surface of the concrete slopes toward the center drain. At these points discharge from the side gutters into the center drain is made through 5-in. iron pipe.

After this second instance of inward thrusting of the side walls brass studs were set at 100-ft. intervals in both sides of the tunnel for the full length. The width of the tunnel between these studs is being checked periodically so that there will be warning if any further movement occurs.

The work described in the foregoing has been under the supervision of W. H. Kirkbride, engineer of maintenance-of-way and structures, Southern Pacific Company.

Unusual Foundation Procedure for 71-Story Building

Foundations for Manhattan Company Building, New York City, Built Underneath Old Buildings During Progress of Wrecking Operations So That Steel Erection Began as Soon as Site Was Cleared—Exceptionally Large Cylinders Sunk by Jacking

By W. T. McIntosh

Engineer, Spencer, White & Prentis, Inc., Engineers and Contractors, New York City

BY ADAPTING underpinning procedure to the construction of new foundations and thus operating under the old buildings on the site, four months' time was saved in building the 71-story Manhattan Company Building at 40 Wall St., New York. On one half of the site, the buildings were vacated by the tenants on May 1, 1929, and the large building occupying the other half was vacated on May 16, 1929. On these respective dates wrecking was begun at the roofs; also foundation construction in the basements. When the demolition of the large building had been completed on June 15, the foundations were ready to receive the steelwork, and on June 17 steel erection began. All the 71 stories of steel frame were completed on Nov. 1, 1929, and before May 1, 1930, the building will be ready for tenants.

In making the foundations ready for steel two days after completion of wrecking, the contractors employed caissons capable of carrying the column loads for the first twenty stories, and then, while these stories were being erected, enlarged the small caissons to the designed size for full load. This procedure was the outstanding contribution of the foundation contractors to the early commencement of steel erection and is described at length.

Location and Conditions at Site

The Manhattan Company Building has a 150-ft. frontage on Wall St. and extends 250 ft. through to Pine St. As stated, it is 71 stories (925 ft.) high. Wall and Pine Sts. are narrow and busy streets in the heart of the financial district. As indicated on the foundation plan (Fig. 1), the west half of the site was occupied by six-story and one three-story, old-style, heavy brick buildings. The old Manhattan Bank Building, twelve stories high, occupied the east half of the site and was a very heavy stone and brick building of the wall-bearing type, with heavy interior piers of masonry. Water level was 22 ft. below the average street grade. The soil was fine sand and clay (typical Manhattan

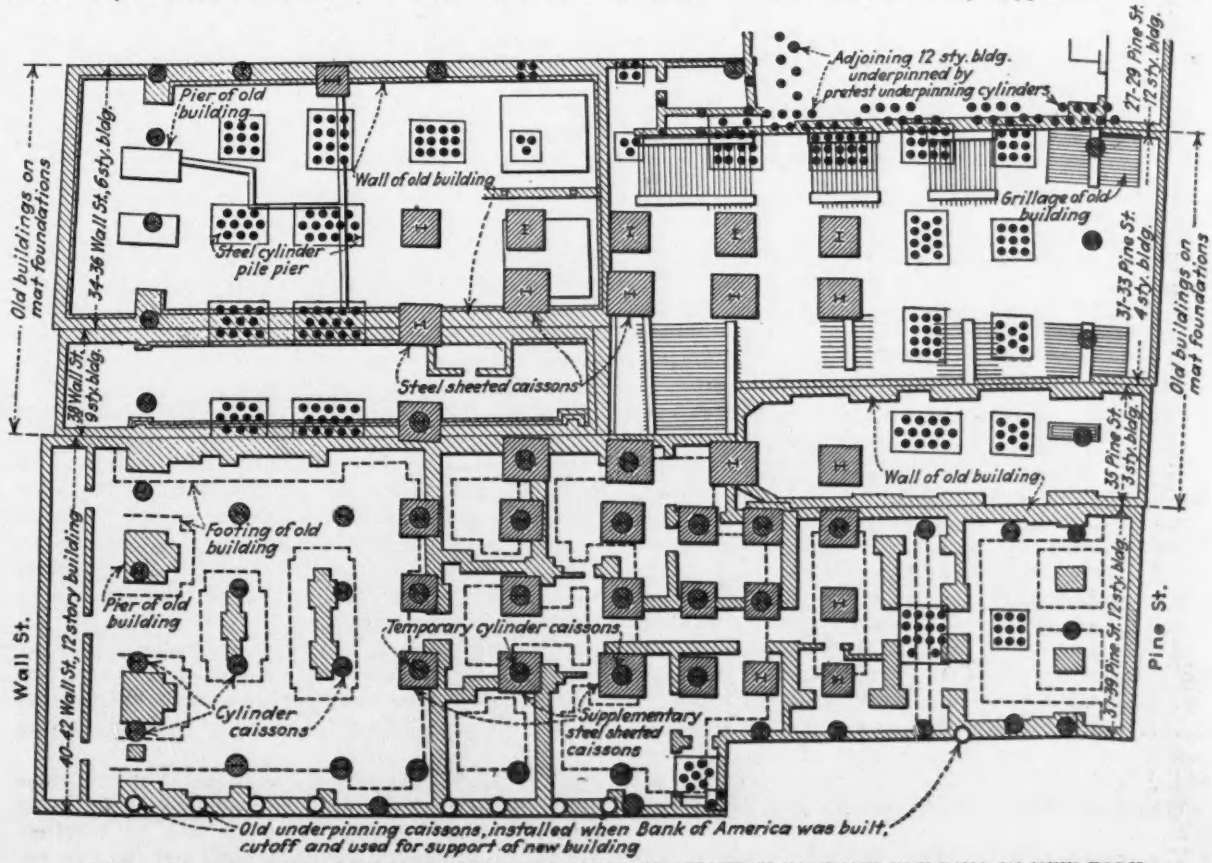

Adjoining 12 sty. bldg. underpinned by pretest underpinning cylinders
27-29 Pine St. 12 sty. bldg.
Pier of old building
Wall of old building
Steel cylinder pile pier
Grillage of old building
Old buildings on mat foundations
34-36 Wall St. 6 sty. bldg.
31-33 Pine St. 4 sty. bldg.
38 Wall St. 9 sty. bldg.
Steel sheeted caissons
35 Pine St. 3 sty. bldg.
Wall of old building
Old buildings on mat foundations
Footing of old building
Pier of old building
Temporary cylinder caissons
Wall St.
40-42 Wall St. 12 story building
Cylinder caissons
Supplementary steel sheeted caissons
37-39 Pine St. 12 sty. bldg.
Pine St.
Old underpinning caissons, installed when Bank of America was built, cutoff and used for support of new building

FIG. 1—PLAN OF TYPES OF FOUNDATIONS FOR 925-FT. MANHATTAN COMPANY BUILDING IN NEW YORK

quicksand) to a depth of 49 ft. below street level and then a hardpan mixture of hard gray clay, gravel and boulders to rock, at an average depth of 64 ft.

These conditions at the site affected construction conditions (1) by curtailing the space for construction operations and (2) by intruding old structures in the way of almost every operation.

The narrow and busy street frontages and adjoining buildings confined construction operations to the building area. Virtually all plant, equipment and materials had to be kept within the buildings, and the congested streets hampered their movement to the site and also the removal of wreckage from the site. With demolition and foundation construction proceeding at the same time, 1,200 men in 24 hours were at times working in the 150x250-ft. plot. Almost everywhere the new foundations for the new building were fouled by the piers, caissons under the existing buildings where necessary; to construct the foundations only to part size—large enough to carry twenty stories of steel—so that steel erection could be begun quickly, and then complete them later to full-load size. The open-caisson method was used, since the space in the old basements and the limited time made the pneumatic method impracticable. This was an innovation in practice in this section of New York City, where compressed air has almost invariably been used, and it was entirely successful.

Foundation Construction Methods

Broadly, the foundation operations divided into (1) sinking steel cylinder open caissons for 60 tower and wall columns, (2) enlarging eighteen of the cylinder caissons by sinking steel-sheeted caissons around them, (3) sinking sixteen steel-sheeted open caissons, (4)

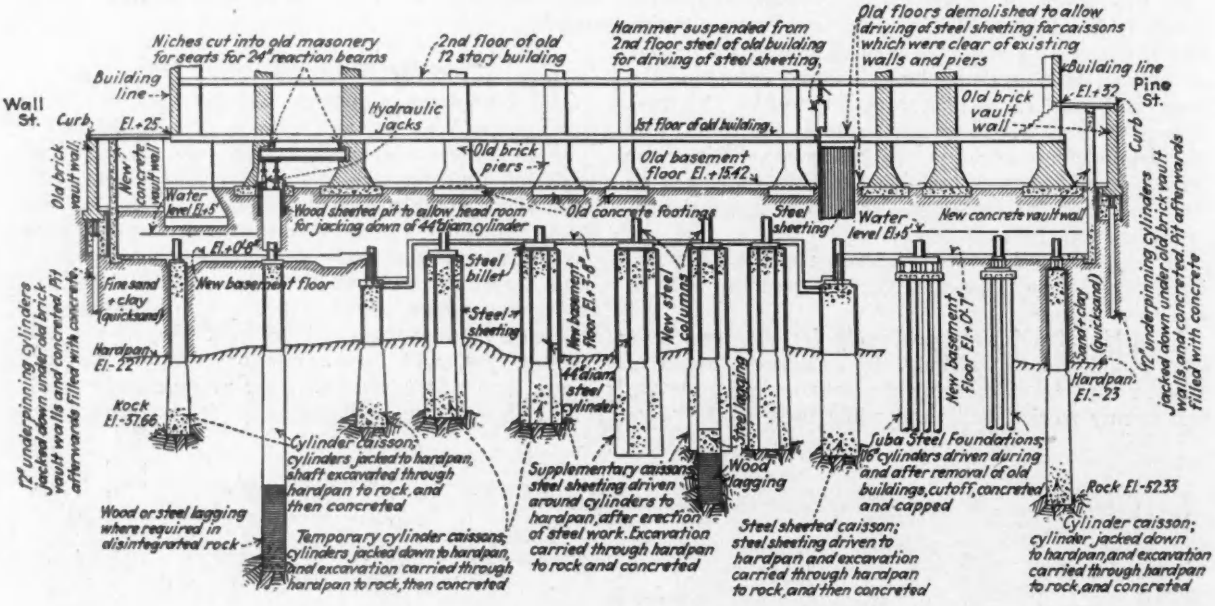

Niches cut into old masonery for seats for 24" reaction beams
2nd floor of old 12 story building
Hammer suspended from 2nd floor steel of old building for driving of steel sheeting.
Old floors demolished to allow driving of steel sheeting for caissons which were clear of existing walls and piers
Building line
Wall St.
Curb
El.+25
Hydraulic jacks
1st floor of old building
Old brick vault wall
Pine St.
El.+32
Old brick piers
Old basement floor El.+13.42
Old brick vault wall
New concrete vault wall
Water level El.+5
Wood sheeted pit to allow head room for jacking down of 44" diam. cylinder
Old concrete footings
Steel sheeting
Water level El.+5
New concrete vault wall
El.+0.48
Steel billet
Fine sand + clay (quicksand)
New basement floor
"Steel" sheeting
New basement floor El.+3.5
New steel columns
New basement floor El.+0.7
Sand + clay (quicksand)
12" underpinning cylinders jacked down under old brick vault walls and concreted. Fit afterwards filled with concrete
Hardpan El.-22
Hardpan El.-23
Rock El.-31.66
44" diam. steel cylinder
Steel lagging
Wood lagging
Cylinder caisson; cylinders jacked to hardpan, shaft excavated through hardpan to rock, and then concreted
Supplementary caisson; steel sheeting driven around cylinders to hardpan, after erection of steel work. Excavation carried through hardpan to rock and concreted
Tuba Steel Foundations; 16" cylinders driven during and after removal of old buildings, cutoff, concreted and capped
Rock El.-52.33
Wood or steel lagging where required in disintegrated rock
Temporary cylinder caissons; cylinders jacked down to hardpan, and excavation carried through hardpan to rock, then concreted
Steel sheeted caisson; steel sheeting driven to hardpan and excavation carried through hardpan to rock, and then concreted
Cylinder caisson; cylinder jacked down to hardpan, and excavation carried through hardpan to rock, and concreted

FIG. 2.—SECTION THROUGH SITE SHOWING FOUNDATION TYPES

walls and spread footings of the old buildings. This interference was particularly great on the portion of the site occupied by the old Bank of Manhattan Building.

Construction Plan and Foundation Types

The requirement of speed prohibited waiting to begin the foundation work until the site had been cleaned and the general excavation had been made, as is usual practice. Instead it was planned to begin installing foundations in the basements as soon as the wreckers began to tear off the roofs. The foundation plan (Fig. 1) called for 76 tower and exterior wall column caissons to solid rock and for 27 steel pile piers for interior columns carrying loads up to 950 tons. The caissons varied in size from 9¾ ft. square to 44 in. diameter. The deepest was 82 ft. (100 ft. below street level) and the shallowest was 40 ft. The greatest column load was 2,300 tons. To keep the caisson sizes down, a 1 : 1½ : 3 concrete was used, loaded to 600 lb. per square inch. The steel pile piers consisted of 16-in. cylinders with ⅜-in. shells, driven to absolute refusal and filled and capped with concrete. The largest pier had sixteen piles.

The construction procedure decided on was to sink constructing 27 steel cylinder pile piers and (5) underpinning and minor foundations. All of these operations, except some of the work on the sites of the old low buildings which were quickly wrecked, it is to be remembered, were performed underneath buildings being torn down or new steel structure being erected.

Sinking Cylinder Caissons—The reason for the use of cylinder caissons for the bulk of the foundations was that they could be jacked down in low headroom, the old walls and piers being used as reaction abutments. To drive steel sheeting would have required a headroom of 40 ft., involving much cutting out of walls and piers.

Cylinders 44 in., 48 in. and 52 in. in diameter were used. For the lighter column loads these sizes were ample. For columns carrying heavier loads 44-in. caissons were installed as temporary foundations, in order that the steel erection could be started at the earliest possible date, and supplementary caissons were later sunk around them to provide the necessary ultimate carrying capacity.

Recesses or chases were cut in the existing brick walls or piers, in which to start the cylinders, and existing concrete spread footings were cut out as required. Where this cutting of the walls, piers and footings les-

sened their carrying capacity enough to justify them, shores or needles were installed to prevent settlement or undue strains in the old structure. In some cases pits were dug under foundations instead of through them.

To provide reactions for jacking down the cylinders, notches were cut in the masonry walls and piers above, and in these were set steel I-beams, spanning across the cylinders. In some instances reactions could not be found for simple beams except on excessively long spans, and multiple reaction beams were used. Against these the cylinders were jacked down with hydraulic rams operating at pressures up to 6,000 lb. per square inch. Pressure was supplied from a central plant which consisted of an electrically operated, triplex hydraulic pump, an air compressor, an air reservoir and a pneumatic-hydraulic accumulator. The latter device maintained constant hydraulic pressure, automatically starting and stopping the hydraulic power pump as required.

The cylinders were excavated by hand by men inside them. Extreme care was exercised to keep the bottoms of the cylinders well below the level of excavation at all times, so that no boiling of the quicksand would occur, and at the least sign of boiling a blanket of gravel was dumped into the caisson. Water was removed by steam siphons discharging into settling tanks and thence into the sewers. Materials were hoisted in buckets by electric winches.

Satisfactory progress was made as long as the cylinders were in clear quicksand, but as soon as an obstruction of any kind was met there were serious difficulties. Excavation of the cylinders puddled the material and aggravated its tendency to boil, and the danger of boiling, of course, prevented digging to the bottom so that obstructions could be exposed and removed. If the obstruction was large and presented a surface normal to the cylinder, progress was halted. If smaller and oblique to the cylinder, an increase in jacking pressure would advance the cylinder, but only by distorting it. As soon as there were signs of buckling in the cylinder, heavy reinforcing bands were put in, and if buckling continued, steel cross-struts were installed to brace the bands. If the buckling became excessive before reaching hardpan, it was necessary to install a new smaller cylinder inside the first.

The obstructions were principally boulders, most of them just above the hardpan, so that it was possible to get most of the cylinders nearly down before serious difficulties occurred. It was then a case of fighting the way down by all the various methods which could be devised, in the meantime maintaining all the jacking pressure which the cylinders would stand without crippling and for which reactions were available under the old buildings. A maximum of 300 tons' jacking pressure was employed. In one instance 1½-in. oak sheeting with radial tongue-and-groove joints was driven inside the cylinder, but was only partly successful. In several instances steel sheeting, made up of pieces of steel plate bent to the radius of the cylinders, was driven, after

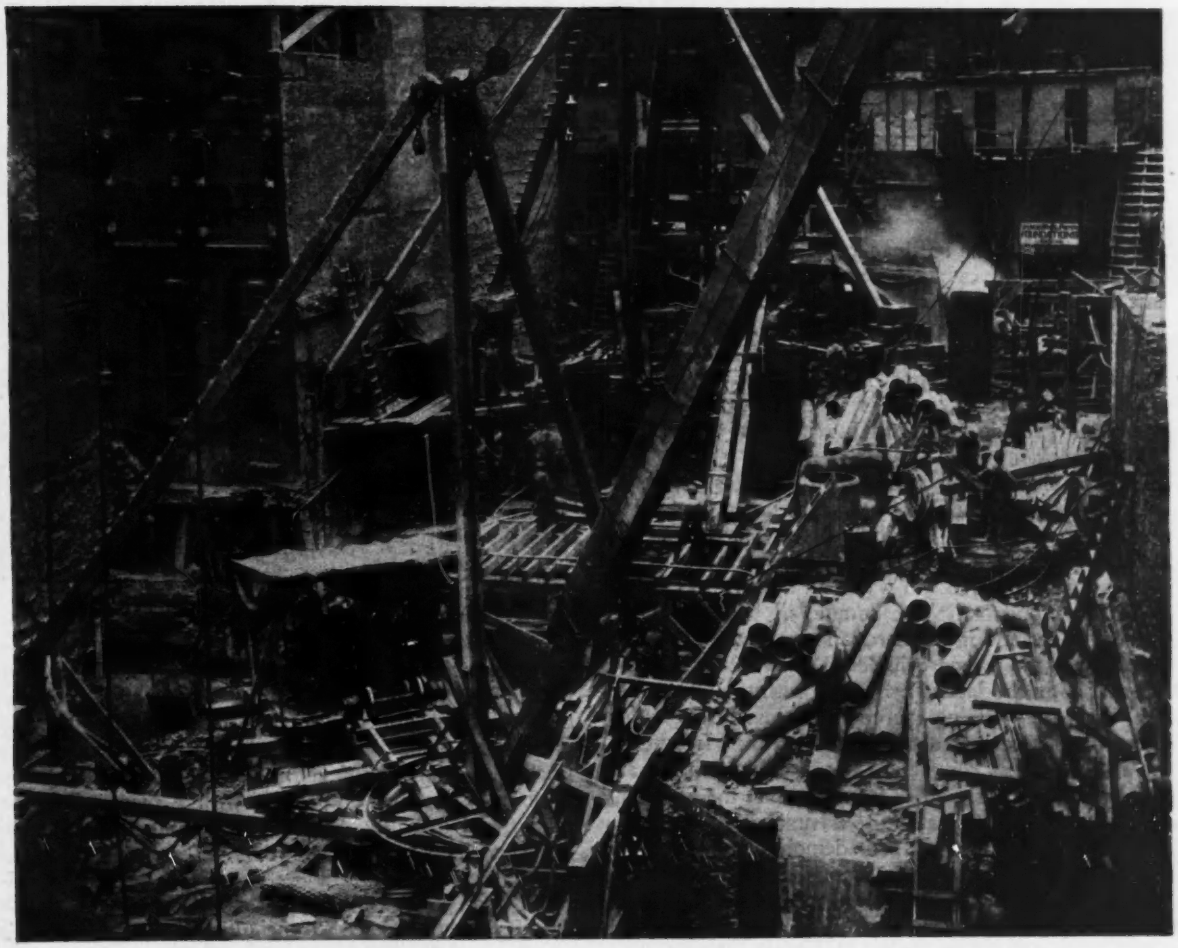


FIG. 3—CONGESTION OF FOUNDATION SITE FOR MANHATTAN COMPANY BUILDING

being burned out to fit around the obstruction, the shape of which was determined by sounding with bars. This was more successful. In one instance the cylinder itself was burned out to fit around a boulder at the top of the hardpan. One cylinder had to be abandoned entirely and an adjacent cylinder was installed to replace it, with a heavy cantilever to carry the column.

The method of jacking down cylinder caissons was successful only because the boulders were in the bottom of the quicksand, close to the hardpan. Had the boulders been higher in the sand, the caissons could not have been put down in that way.

When hardpan was reached, the material was carefully cut out under the edge of the cylinder, which was then

FIG. 4—LOOKING DOWN 44-IN. CYLINDER CAISSON 82 FT. DEEP

jacked down into the hardpan from 1 to 3 ft. to cut off the water. The excavation was then carried down as a shaft through the hardpan and soft rock to hard rock. No continuous sheeting was used in the hardpan, but it was necessary, where disintegrated rock was encountered, to put in steel lagging, braced across the pits with light I-beams. Rock, when reached, was leveled and benched to provide full level bearing for the concrete on sound rock.

Some of the cylinder caissons on the sites of the old six-story buildings could not be jacked down because the wrecking of these low buildings proceeded so fast that the necessary reaction could not be obtained. These cylinders were driven from water level down to hardpan by means of pneumatic pile hammers. The excavating in the cylinders and in the hardpan was done in the same manner as in the jacked cylinders. The same difficulties were met as in the jacked cylinders, with the added difficulty that the driving force was insufficient when obstructions were met above the hardpan. In one instance obstructions completely stopped the cylinder and it was necessary to rig an A-frame against the adjoining building and resort to jacking to advance it.

General Excavation—When demolition of the old buildings had progressed far enough to permit, steam shovels started general excavation. The shovel excavation was carried down to 27 ft. below street, to which level the water had been lowered by continuous pumping throughout the job. From this grade, steel-sheeted pits were sunk to the elevation of finished tops of piers, preparatory to placing the steel billets on the cylinder caissons, the billets being larger than the cylinder piers which supported them.

On June 15 demolition of the old buildings was completed. Two days later, on June 17, the foundations were ready for steel and the steel contractor began the erection.

While the billets, the first lift of columns and first floor steel were being placed, the foundation contractors continued with general excavation by hand, leaving berms against the outer walls of the old sidewalk vaults, which were underpinned by the pretest method. After the steel erection derricks had been raised above the first floor, general excavation was resumed and completed.

Enlarging Cylinder Caissons—As soon as subgrade was reached the cylinders installed as partial-load foundations were enlarged by putting down around them square caissons as indicated in Fig. 2. These enlargements were begun as soon as the general excavation had reached subgrade. Steel sheet-pile boxes were driven around the cylinder from subgrade to hardpan about 18 ft. below. These were excavated and the shafts then

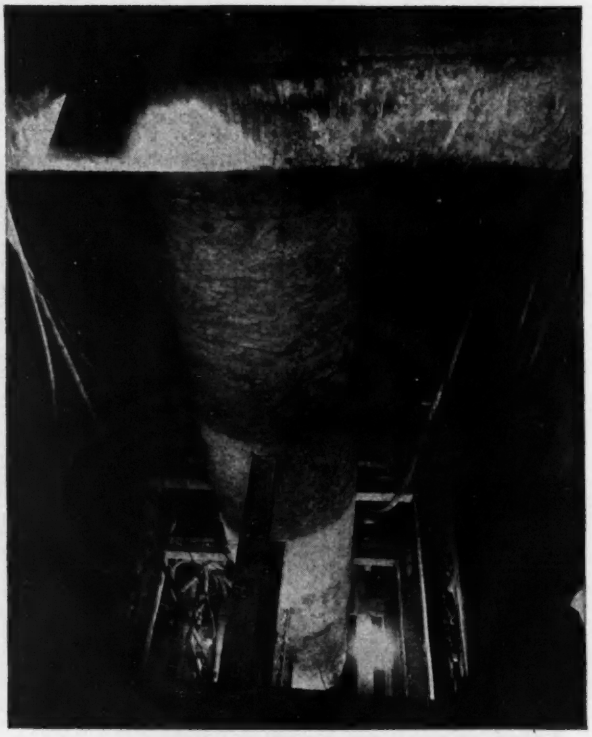


FIG. 5—LOOKING DOWN ENLARGEMENT CAISSON AROUND 44-IN. CYLINDER PIER

continued without sheeting down through the hardpan to rock. The supplementary caissons were then concreted to a point about 3 in. below the billets. After the concrete had set, the 3-in. space was dry-packed with a rich, fairly dry mixture of cement, sand and small gravel, thoroughly rammed into place with a piece of 2x4-in. timber and a maul. Experience in underpinning work had demonstrated that there is no shrinkage in such dry-packing on setting and that the dry-packing can be relied upon to transmit to the supplementary portion of the pier its full share of the ultimate load. With the pouring and dry-packing the foundation was complete.

Steel-Sheeted Caissons—In a few instances the locations of large caissons for the new building were such that they could be sunk inside the old buildings without undue interference with their walls. In such cases, pits were excavated down to water level, horizontally wood sheeted, of sizes such that steel sheet piling could be driven inside them from water level.

When water level was reached 30 or 35 ft. steel sheet piles were set up to form the caisson, the first and second floors of the old building being removed over the pit so that the sheet piling could be entered. The sheeting was alternately driven and excavated down to hardpan and was braced with rings of timber about 4 ft. center to center. The greatest care was exercised to keep the

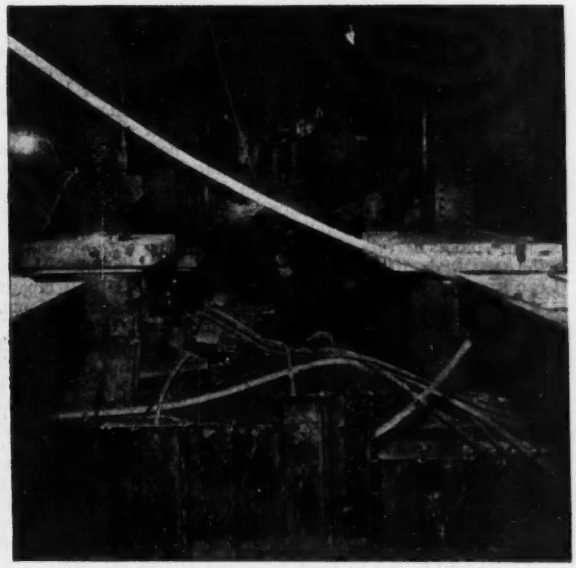


FIG. 6—CYLINDERS WITH BILLETS SET AND COLUMNS ERECTED

sheeting far enough below the excavation to prevent boiling of the material in the bottom. The vibration of driving and the puddling of material during excavation increased the tendency of the quicksand to boil. When hardpan was encountered the steel sheeting was driven well into it to form a seal, and from there down a shaft of the same size was sunk through the hardpan and soft rock without sheeting, except where soft strata were encountered. The bottoms were leveled or benched in sound, hard rock.

There were a few caissons on the site of the old three- and six-story buildings in which only the wood-sheeted pits to water level were sunk under the buildings, the driving of the steel-sheeted caissons being delayed until it could be done in the open. Also along the east line of the site a number of underpinning caissons supporting the old Bank of America Building, which was demolished, were encountered. These were cut off and used to support the new building.

Steel Pile Piers—The pile piers comprised groups of from three to fifteen steel cylinders, 16 in. in diameter and $\frac{3}{8}$ in. thick, driven to absolute refusal. After being driven, they were excavated by blowing out the material with compressed air, literally exploding large volumes of air in the cylinders, and were filled with concrete. The cylinders were then cut off by oxyacetylene burners, covered with $\frac{3}{4}$-in. steel plates and capped with reinforced concrete. A total of 262 cylinders was driven.

While the caissons were being sunk the adjoining building, known as 27-29 Pine St., was underpinned. This is a twelve-story building of heavy construction, on a 4-ft. thick concrete mat reinforced with plate girders. The length of wall adjoining the new structure was 100 ft. and the estimated weight to be underpinned was 3,000 tons.

Pretest underpinning was used throughout, this being the only economical method by which the work could be done in quicksand without serious settlement of the structure. This type of underpinning, which is patented, consists of sectional steel cylinders, jacked down to a predetermined minimum depth and load capacity, excavated, concreted, tested and wedged against the foundations of the structure, the full test load being maintained until the wedging is completed.

Underpinning pits 4x4 ft. were sunk to a depth of 6 ft. below the wall to be underpinned. Only three such pits were opened at a time and were at least 20 ft. apart. In each pit a 12-in. steel cylinder, in 4-ft. long sections, with internal cast-steel sleeve connections, was jacked down to hardpan by a hydraulic jack, operating from the power pump and accumulator. When the cylinder had been seated in the hardpan and completely excavated, it was concreted. By means of hydraulic jacks the cylinder was then put under a test load of 90 tons, 50 per cent in excess of the 60-ton load which it was designed to carry. Then, while the full test load was held on the jacks, a short I-beam column was placed on end between the jacks, and steel wedges were driven between it and the plate under the foundation until the load was transferred from the jacks to the column. This method of wedging reduces settlement to the absolute minimum by compressing and holding in compression the material under the cylinder itself, allowing no opportunity for rebound. Fifty underpinning cylinders were installed and the maximum settlement of the building was $\frac{1}{8}$ in.

On July 31, 1929, all excavation and foundation work was completed, $2\frac{1}{2}$ months after full possession of the site was obtained and wrecking of the old Bank of Manhattan Building started. In view of the many difficulties to be overcome—running sand, boulders, rock far below the street, extreme congestion within the site and working under the old and new buildings—this is a remarkable record. Its accomplishment saved fully four months in the time of construction of the building.

The foundation and underpinning work were done by Spencer, White & Prentis, Inc., under the direction of J. C. Weaver, general superintendent; Anton Gunther, superintendent, and W. T. McIntosh, engineer. Starrett Brothers, Inc., was the builder. Moran & Proctor were consulting engineers on the foundtations. The building was designed by H. Craig Severance, Inc., architect, and Yasuo Matsui, associate architect.

Grade-Crossing Fatalities Dropped in 1929

Reports for the year 1929 filed by the railroads with the Interstate Commerce Commission reveal that, although both the number of accidents at highway grade crossings and the number of persons injured increased during the year 1929, the number of persons who lost their lives in such accidents was reduced 3.2 per cent compared with 1928. Detailed figures are: accidents 5,975, compared with 5,800 during 1928; persons injured, 6,804 and 6,666; fatalities, 2,485 and 2,568.

Text of Supreme Court Decision in Chicago Lake Diversion Case

Complaining Lake States Win on Contention of Unlawful Diversion for Sewage Disposal, but Lose on Other Conditions—District Loses on Effort to Secure More Time to Build Sewage-Works

DIVERSION of water from Lake Michigan through the Chicago Drainage Canal for the benefit of some 50 other communities in the Chicago Sanitary district, the U. S. Supreme Court ruled on April 14, must be limited by Dec. 31, 1930, to 1,500 cubic feet per second (1,500 sec.-ft.) in addition to water pumped from the lake for municipal supply. On and after July 1, 1930, diversion must not exceed 6,500 sec.-ft., and on and after Dec. 31, 1935, it must not exceed 5,000 sec.-ft. The limit as of the close of 1935 is qualified by the words "unless good cause be shown to the contrary." To a certain extent, the court will entertain petitions for relief from the terms just summarized, as may be seen by referring to the full statement of the decree given at the close of this article.

This ruling is a sequel to the decision of the Supreme Court on Jan. 14, 1929, and is based on subsequent findings by Charles E. Hughes, master in the case, submitted Dec. 17, 1929. The suit was brought against the State of Illinois and the Sanitary District of Chicago many years ago by some of the states bordering on the Great Lakes, with which all the other Lake states except Illinois subsequently joined. Before the decision of 1929, the states bordering on the lower Mississippi River joined as codefendants. The complainants claimed that the diversion lowered the level of the lakes, thus interfering with navigation, and asked for an injunction against any diversion for sewage-disposal purposes. Later, the complainants demanded that water pumped from Lake Michigan for municipal supply be returned to the lake afterward as treated sewage. This demand the court absolutely denies, but it declines to forbid all diversion for sewage disposal, adhering to its earlier decision that the interests of navigation in the harbor of Chicago demand some diversion to prevent injury. Except for the omission of some details, relating chiefly to progress of construction of sewage-works now under way or projected, the court decree follows the findings of Mr. Hughes as master.

It may be noted in passing that the decision of 1929 and the present decree were considerably at variance with a report made to the court by Mr. Hughes before the 1929 decision was handed down. It should also be noted that Mr. Hughes, who became Chief Justice of the United States after submission of his findings, took no part in the decree; also that the current opinion was written by Associate Justice Holmes, and that, as in the original decision of 1929, there was no dissenting opinion. (For lengthy abstracts of previous reports and decisions see *Engineering News-Record* as follows: Hughes' first report, Dec. 1, 1927, p. 980; original decision, Jan. 24, 1929, p. 146; Hughes' second report, on which decree is based, Dec. 19, 1929, p. 983).

In the opening part of the current decision the court, after referring to its decision of 1929, holding that the district was inflicting losses on the complainants and violating their rights in diverting 8,500 sec.-ft. or more from Lake Michigan, and mentioning the master's report, said (with some omissions, chiefly of portions summarizing the master's recommendations):

Opinion of the Court

The defendants have submitted their plans for the disposal of the sewage of Chicago in such a way as to diminish so far as possible the diversion of water from the lake. In the main these plans are approved by the complainants. The master has given them a most thorough and conscientious examination. But they are material only as bearing on the amount of diminution to be required from time to time and the times to be fixed for each step, and therefore we shall not repeat the examination. It already has been decided that the defendants are doing a wrong to the complainants and that they must stop it. They must find out a way at their peril. We have only to consider what is possible if the State of Illinois devotes all its powers to dealing with an exigency to the magnitude of which it seems not yet to have fully awaked. It can base no defences upon difficulties that it has itself created. If its Constitution stands in the way of prompt action it must amend it or yield to an authority that is paramount to the state.

The defendants' exceptions deal with the extent to which the diversion of water should be reduced and to the time at which the reductions should take place. They argue that a recent rise in the level of Lake Michigan should be taken into account. This cannot be done. Apart from the speculation involved as to the duration of the rise, there is a wrong to be righted, and the delays allowed are allowed only for the purpose of limiting, within fair possibility, the requirements of immediate justice pressed by the complaining states. These requirements as between the parties are the constitutional right of those states, subject to whatever modification they hereafter may be subjected to by Congress acting within its authority. It will be time enough to consider the scope of that authority when it is exercised. In present conditions there is no invasion of it by the former decision of this court, as urged by the defendants. . . .

These recommendations [by the master] we approve within the limits stated above, and they will be embodied in the decree. The defendants argue for delay at every point, but we have indicated sufficiently why their arguments cannot prevail. The master was as liberal in the allowance of time as the evidence permitted him to be.

The exceptions of the complainants go mainly to a point not yet mentioned. The sewage of Chicago at present is discharged into a canal that extends to Lockport on the Des Plaines River (which flows into the Illinois, which in its turn flows into the Mississippi) . . . It is partially to oxidize and carry off this sewage that the main diversion of water is made. The complainants demand that this diversion cease, and the canal be closed at Lockport, with an incidental return of the Chicago River to its original course. They also argue that what is called the domestic pumpage after being purified in the sewage-works be returned to the lake. These demands seem to us excessive upon the facts in this case. The master reports that the best way of preventing the pollution of navigable waters is to permit an outflow from the drainage canal at Lockport, and that the interests of navigation in the Chicago River as a part of the port of Chicago will require the diversion of an annual average of from 1,000 to 1,500 sec.-ft. in addition to domestic pumpage after the sewage-treatment program has been carried out. The canal was opened at the beginning of the century, 30 years ago. In 1900 it already was a subject of litigation in this court. The amount of water ultimately to be withdrawn unless Congress may prescribe a different measure is relatively small. We think that upon the principles stated in Missouri v. Illinois, 200 U. S. 496, 520, *et seq.*, the claims of the complainants should not be pressed to a logical extreme without regard to relative suffering and the time during which the complainants have let the defendants go on without complaint.

Perhaps the complainants would not be very insistent with regard to the 1,000 or 1,500 sec.-ft. which earlier in this case they seemed to admit to be reasonable, if their demand were allowed that the domestic pumpage be purified and returned to the lake—a demand not contemplated by their bill. But purification is not

absolute. How nearly perfect it will be with the colossal works that the defendants have started is somewhat a matter of speculation. The master estimates that with efficient operation the proposed treatment should reach an average of 85 per cent purification and probably will be 90 per cent or more. Even so we are somewhat surprised that the complainants should desire the effluent returned. The withdrawal of water for domestic purposes is not assailed by the complainants and we are of opinion that the course recommended by the master is more reasonable than the opposite demand. If the amount withdrawn should be excessive, it will be open to complaint. Whether the right for domestic use extends to great industrial plants within the district has not been argued but may be open to consideration at some future time.

We see no reason why costs should not be paid by the defendants, who have made this suit necessary by persisting in unjustifiable acts (North Dakota v. Minnesota, 263 U. S. 583).

Terms of the Decree

A decree will be entered to the effect that, subject to such modifications as may be ordered by the court hereafter,

1. On and after July 1, 1930, the defendants, the State of Illinois and the Sanitary District of Chicago, are enjoined from diverting any of the waters of the Great Lakes-St. Lawrence system of watershed through the Chicago Drainage Canal and its auxiliary channels or otherwise in excess of an annual average of 6,500 sec.-ft. in addition to domestic pumpage.

2. That on and after Dec. 31, 1935, unless good cause be shown to the contrary, the said defendants are enjoined from diverting as above in excess of an annual average of 5,000 sec.-ft. in addition to domestic pumpage.

3. That on and after Dec. 31, 1938, the said defendants are enjoined from diverting as above in excess of the annual average of 1,500 sec.-ft. in addition to domestic pumpage.

4. That the provisions of this decree as to the diverting of the waters of the Great Lakes-St. Lawrence system or watershed relate to the flow diverted by the defendants exclusive of the water drawn by the city of Chicago for domestic water-supply purposes and entering the Chicago River and its branches or the Calumet River or the Chicago Drainage Canal as sewage. The amount so diverted is to be determined by deducting from the total flow at Lockport the amount of water pumped by the city of Chicago into its water mains and as so computed will include the runoff of the Chicago and Calumet drainage area.

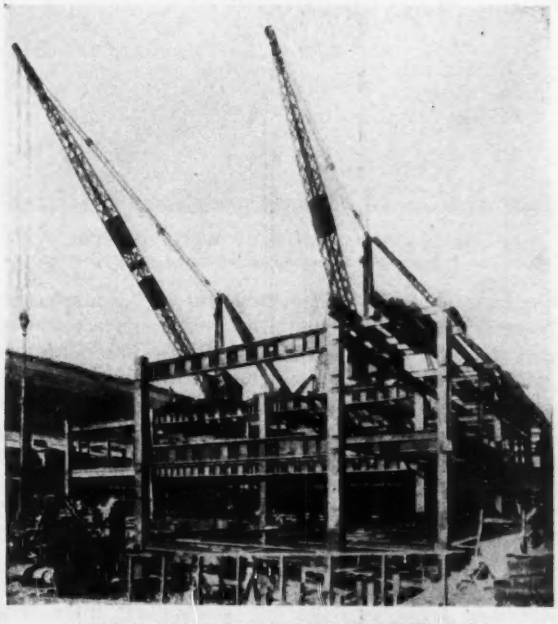
5. That the defendant the Sanitary District of Chicago shall file with the clerk of this court semi-annually on July 1 and Jan. 1 of each year, beginning July 1, 1930, a report to this court adequately setting forth the progress made in the construction of the sewage-treatment plants and appurtenances outlined in the program as proposed by the Sanitary District of Chicago, and also setting forth the extent and effects of the operation of the sewage-treatment plants, respectively, that shall have been placed in operation, and also the average diversion of water from Lake Michigan during the period from the entry of this decree down to the date of such report.

6. That on the coming in of each of said reports, and on due notice to the other parties, any of the parties to the above-entitled suits, complainants or defendants, may apply to the court for such action or relief, either with respect to the time to be allowed for the construction, or the progress of construction, or the methods of operation, of any of said sewage-treatment plants, or with respect to the diversion of water from Lake Michigan, as may be deemed to be appropriate.

7. That any of the parties hereto, complainants or defendants, may, irrespective of the filing of the above-described reports, apply at the foot of this decree for any other or further action or relief, and this court retains jurisdiction of the above-entitled suits for the purpose of any order or direction, or modification of this decree, or any supplemental decree, which it may deem at any time to be proper in relation to the subject matter in controversy.

Bridge Cranes Erect Unusual London Exhibition Building

THE latest addition to the group of exhibition buildings in London, known as the Olympia, is a notable structure, architecturally and structurally. The building is four stories high and faces on Hammersmith Road, where it has a frontage of 326 ft. It is approximately 175 ft. deep. The frame of structural steel is inclosed with cast stone, some units of which weigh as much as 5 tons. Horizontal rather than vertical lines characterize the façade. These result from continuous horizontal windows about 5 ft. high, those on the third floor being about 130 ft. long and on the second floor about 100 ft. long. The difference in length results from the arrangement of the stair wells, which is novel. Thus these stair wells are grouped at the four corners of the building and each ends with the floor it serves. The tallest well is in the corner of the building, the others ranged alongside it, each one story shorter than the preceding one. By this arrangement, on each successive floor the space over the stairwell to the floor below is saved and each floor empties itself of people independently. It is also planned that these stair wells will serve as a series of internal stepped buttresses for the walls of the building.



TWO 20-TON BRIDGE CRANES ERECTING LONDON EXHIBITION BUILDING

The steelwork in the building is very heavy, and speed of erection was a definite objective. As a result the steel contractors, Dorman, Long & Co., are using two 20-ton cranes that were developed and used in connection with the erection of the new Tyne bridge at Newcastle, which was opened last year. As a direct result of the use of these cranes an average of 500 tons of steel per week has been made on the Olympia extension, compared with the normal rate in London of 100 tons per week.

A total of 7,300 tons of steel is involved in this structure. The main interior columns are spaced 50 ft. each way and are composed of three I-beams reinforced with heavy flats riveted to the webs and spaced by wide flange plates. The bottom sections of these columns are about 58 ft. long and weigh 26 tons. They have slab bases measuring 4x4½ ft. by 8½ in. thick, which rest on I-beam grillages. The main girders, made up of plates and angles, have an approximate depth of 4 ft. and a width of 20 in. Some of the girders weigh 22 tons each.

Holland Tunnel Receipts During 1929

Income for the Holland vehicular tunnel under the Hudson River at New York City during 1929 totaled $6,120,005. Operating expenses were $1,528,684, leaving a profit of $4,591,321. The tunnel cost $48,000,000 and at the present rate should be paid for by the end of 1937.

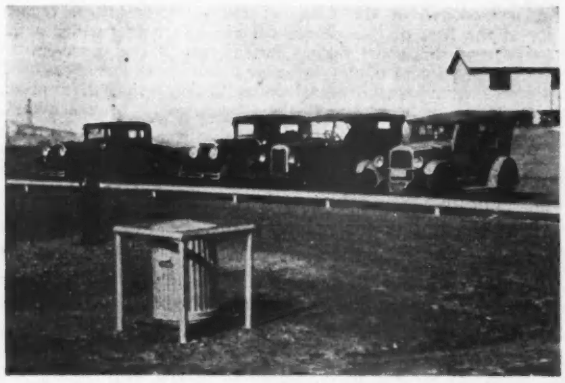
From Job and Office

Hints That Cut Cost and Time for the Contractor and Engineer

Welded Pipe Structures Widely Used in the Oilfields

IN THE oilfields of California metal pipe of varying sizes and strengths welded hastily together in the desired shapes is adapted to innumerable uses. One of the accompanying illustrations shows a railing of the type built up to protect refuse cans in camps, and in the background a parking rail for automobiles. The other picture illustrates construction in a high-pressure 16-in. gas-pipe line.

The refuse can railing is made entirely of 1½-in. pipe welded as shown, the horizontal pieces connecting the tops of pipe posts which have been firmly planted in the



REFUSE CAN RAILING AND AUTO PARKING RAIL

earth. One of the four sides is left open so that the can may be removed readily for emptying.

The parking rail is made of 8-in. pipe and is supported on posts made of short pieces of 4-in. pipe set firmly in the ground, with their tops cut on a curve to facilitate welding into the 8-in. line. The open ends of the latter are closed by making a deep V-cut in the metal near the end and welding in a tapered strip of the same material. The coat of aluminum paint which now is applied to almost all exposed metal structures in the oilfields hides any little irregularities at the welds.

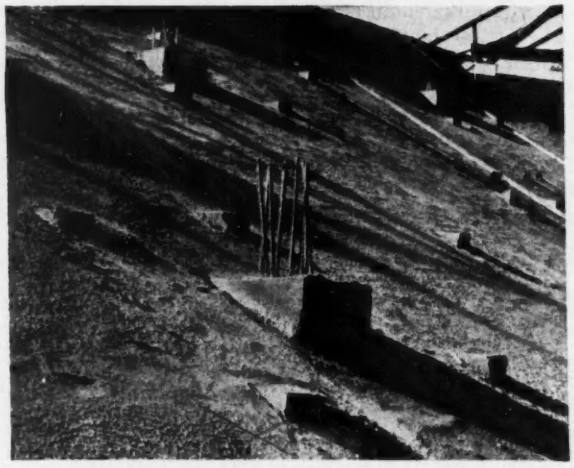
The illustration of the 16-in. gas pipe line "T" shows

TYPICAL JOINT STRUCTURE IN 16-IN. GAS PIPE

the method by which the welder in the oil fields braces and strengthens joints of this sort. That portion of the assembly marked "brace" is a curved piece of metal cut with the torch from a short length of the 16-in. pipe. By welding it into place as shown, the rigidity and strength of the assembly have been increased greatly without much additional cost. The short lengths of metal straps whose edges are welded to the pipe surface are found materially to increase the stiffness of the joints. A connection with the two 45 deg. joints has been found much stronger than a direct, unsupported right-angled connection. These gas pipes operate under pressures of more than 400 lb. per sq.in.

Gunited Column Footings Provide Continuous Reservoir Lining

REQUIRED by design to provide a gunited reservoir lining without interruption at the bases of the columns supporting the roof, the contractor on a small water-supply reservoir in Burlingame, Calif., elected to construct the footings and column bases by the same method. The purpose of the design was an effort to eliminate the point of weakness usually caused by the



COLUMN BASE BUILT UP WITH GUNITE
Four small bases are for temporary shores to support roof.

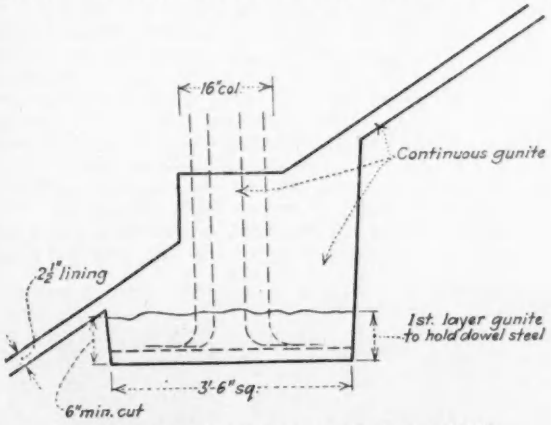
joint between lining and columns in such construction. The method of construction used by the contractor eliminated the expense of building runways for distributing small batches of mixed concrete to 103 column footings over an area that had to be traversed in guniting the lining. As a result the process consisted of shooting the footings below the lining, the lining and the column pedestals in one continuous operation.

Column footings on the slopes were 3 ft. 6 in. square with a 6-in. minimum depth on the lower side. Depth on the upper side depended on the slope, which was 1½ to 1 in cut and 2½ to 1 on the earth dam. After excavating these footings the reinforcing mats were placed and the column dowel steel was fastened in posi-

tion. A 6-in. layer of gunite was placed on the bottom of the footing to hold the reinforcing steel in position.

Wire fabric of 4x4-in. mesh was spread over the reservoir surface, the dowel steel reaching above the elevation of the lining. Following these preparations the work of lining was started and, as the 2½-in. layer was extended to the location of each column, the footing was gunited as a part of the operation.

After completing the guniting at each column to the upper surface of the lining a small form was set on the slope around the dowel steel and a base was built up to support forms for a 16-in. column. The result of this means of footing construction is shown in the accompanying illustration. One of the interesting features developed by the contractor for his own use also is shown in the illustration. The small, horizontal bases spaced



SECTION THROUGH FOOTINGS AND LINING

around the column base were introduced by the contractor to provide for 6-in. temporary wooden shores to support the roof slab during construction, before the concrete columns could take the load. These were gunited in at the time of placing the lining and proved an economical method of securing a firm base for the construction shores.

Use of this method of construction resulted in a lining continuous over the whole surface of the reservoir without interruption by any of the supporting columns. The method proved an economical means of construction; the reservoir is now in use and the resulting watertightness has been very satisfactory.

The design was worked out by C. I. Rhodes, of the Loveland Engineers, Inc., San Francisco. D. S. Clinton, of San Francisco, was the contractor responsible for the method of construction.

Device Speeds Work of Grooving Utility Strips at Sides of Highway

A MULTIPLE guide for marking grooves in the utility strips along the sides of a concrete highway was recently developed during construction work on a state project in California. This work required the grooving of the 8-ft. slabs to facilitate future excavation for utility conduit work. Marking three grooves in each 8-ft. strip for the length of the 5-mile contract, to divide it into 2-ft. sections, was speeded up by a wheeled device developed by the Griffith Co., of Los Angeles, contractor on the job. Features of the scheme and the method of use are shown in the accompanying illustration.

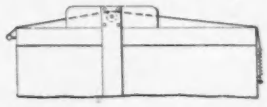
WHEELED GUIDE FOR GROOVING UTILITY STRIPS
Device results in rapid marking and quick moves between settings.

The guide frame consists of two steel bars extending across the slab and three longitudinal timbers which form the guides for the finishing tools. On one end the steel bars form the axles of wheels which run on the header boards and on the other end form handles used to move the device. The timber guides, about 20 ft. long, are suspended from the bars at a distance that places them close to the surface when the handles are supported on blocks at the curb. Planks are provided over each guide timber to provide a working bridge for the finisher. The device is moved along the job on the two wheels by means of the handles on the curb side. It is estimated that this device speeded up the rate of grooving by about 50 per cent.

Development of the guide was chiefly the work of Cliff Bong, resident superintendent for the Griffith Co.

Job and Office Notes

KEEPING THE T-SQUARE in correct position against the side of the drawing board is greatly facilitated by the arrangement shown in the accompanying sketch. A small grooved roller about 1 in. in diameter is fastened to the lower side of the T-square head. Over this is passed a heavy cord, which is fastened to the lower edge of the drawing board with a screw eye. At the upper edge it is tied to a small coil spring or rubber band with sufficient tension to hold the T-square head snug against the side of the board in all positions.



—MORTON SCHWAM, Philadelphia, Pa.

AN ELECTRIC SCREEN for the protection of fish life in streams has been developed by Hugh C. Mitchell, director of fish culture of Oregon, along the lines of similar devices used at hydroelectric power plants. A cable is erected at the mouth of the irrigation ditch, from which chains are suspended at intervals of 15 in., weighted with sash weights to resist the flow of the current. Approximately 9 ft. upstream from the chain electrodes an iron pipe is laid across the bottom of the stream, insulated by sections of common clay conduit. Alternating current at 60 cycles is passed to each electrode and follows a direct line from the chains to the pipe. It is stated that fish, on encountering the area of electrically charged water, immediately turn back and follow the main stream instead of entering the irrigation canal.

DRAFTING ROOM COSTS in the Army Ordnance Department have been decreased by the expedient of printing typical outlines of frequently used parts, such as gages, so that the draftsman has simply to fill in a few dimensions and notes rather than make a complete outline drawing. This plan can easily be adapted to any drafting room which must frequently produce drawings differing only in minor details. The outlines, with blank dimensions, can be run off by any of a number of commercial printing methods, the printing being done on the rough side of the tracing cloth. Printing ink of the best quality must be used to avoid smudging.

Letters to the Editor

Friction on Bridge Expansion Plates

Sir—In *Engineering News-Record* for March 27, 1930, p. 536, T. E. Stanton, materials and research engineer of the California State Division of Highways, tells of tests being made under his direction on starting and sliding friction of bronze expansion plates used in bridge construction.

The writer believes it would be interesting to the profession if specimens made of the newer rustless steels such as chrome-nickel steel were to be included in the above tests. This material is said to be rustless under all ordinary conditions and to take and keep indefinitely a high degree of polish; it is reported to be of very high strength, ductile and tough and, being a rolled product, would probably be more reliable than cast bronze. Its cost is high compared with ordinary steel, but it would probably cost no more than high-grade bronze; perhaps not as much. Anyway, such plates are usually so small a part of the cost of the entire bridge that any difference in the cost would generally be negligible.

The tests by Mr. Stanton, when published, will probably reveal whether the various bronzes develop sufficient oxidation under working conditions to affect materially the coefficient of friction. In order to simulate working conditions it would be well if such tests were made so that there would be present the electrolytic action which takes place when bronze and steel are brought into contact in the presence of atmospheric moisture (especially in salt-laden air by the sea), as they are in the case of a steel-bridge bearing, resulting in the rapid rusting of the steel in the vicinity of the bronze. In this respect again the rustless steels would seem to offer an advantage over the bronze.

If such tests on rustless steels could be included by Mr. Stanton, they would probably yield interesting and valuable results for which the engineering profession would be indebted to him and to the California State Division of Highways.

H. C. TOENSFELDT,
Consulting Engineer.

New York City, April 2, 1930.

* * *

Sir—Mr. Toensfeldt suggests different materials which he thinks should be included in the test. For his information and also for the information of any others who may be interested, the following are the specifications which were drawn up by us covering the plates which we are testing:

Two 6x8-in. and two 6x6-in. plates ½ in. thick to be furnished in each set. One pair of plates to be given polished and the other ground surfaces. Also, one test specimen with each set, 1½x6 in.

	Per Cent
Set No. 1—Standard 1929 Specifications:	
Copper	83.00
Tin	16.00
Phosphorus	0.25
Nickel	0.50
Other elements not over 50 per cent	0.25
Set No. 2—S.A.E. No. 62:	
Copper	86.00 to 89.00
Tin	9.00 to 11.00
Lead (maximum)	0.20
Iron (maximum)	0.06
Zinc	1.00 to 3.00
Phosphorus	....
Set No. 3—Apex No. 44:	
Copper	70.00
Lead	25.00
Tin	5.00
Phosphorus	....
Set No. 4—Apex No. 49 Standard Phosphor Bronze:	
Copper	80.00
Tin	10.00
Lead	10.00
Set No. 5—American Railway Specifications for Journal Bronze:	
Copper	Balance
Lead	15.00 to 25.00
Tin	4.00 to 7.00
Lead, preferably	17.00
Set No. 6—Nickel Alloy:	
Copper	70.00
Nickel	30.00
Impurities	Not over 2.00
Set No. 7—Phosphor Bronze:	
Copper	85.00
Tin	10.00
Lead	5.00
Set No. 8—Aluminum Bronze:	
Copper	85.00 to 87.00
Aluminum	7.00 to 9.00
Iron	2.5 to 4.5
Set No. 9—Stainless Steel.	

Sacramento, Calif., April 10, 1930.

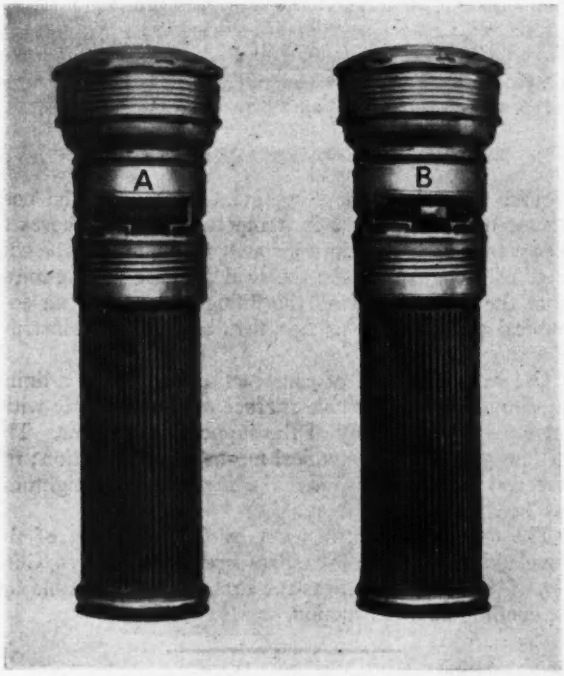
T. E. STANTON,
California State Division of Highways.

Probable Cause of Premature Tunnel Explosions

Sir—Last November a premature explosion occurred on the 15-mile tunnel being driven for the Metropolitan Water District of Boston, which resulted in the loss of five lives. Every precaution was taken on the work in the carrying out of the blasting operations and the general opinion of the trained investigators was that the explosion was caused by a fall of rock from the roof onto a piece of primed explosive.

A few weeks ago a powderman had an electric torch in his hand and was starting to unwind the wires from a stick of dynamite containing a late delay exploder. Hearing a slight hiss (which came from the fuse portion of the detonator), he jerked the cartridge away from him (fortunately away from the rest of the explosives in the heading) and the stick went off in the air; the man was uninjured other than getting a few scraps of copper in his neck.

In experimenting with this torch later, it was found that when the switch was opened to the operating position, if one



TYPE OF ELECTRIC TORCH CAUSING PREMATURE EXPLOSION IN BOSTON WATER TUNNEL
A—Switch off and in safety position. *B*—Switch on.

leg of a detonator wire was in contact with the cover of the torch and the other connected with the plunger switch, the detonator would explode every time. A search through the different headings found only one other torch of a similar construction. I am inclosing two photos I took of this torch. *A* shows switch in safety. Turning this to the right, the plunger *B* is exposed; when depressed to light the lamp, a short can be established between it and the case. We all here now feel certain that the first explosion was caused from the use of a similar torch.

WILLIAM SMAILL,
Chief Engineer,
West Construction Co.

West Rutland, Mass., April 8, 1930.

News of the Week

Boulder Dam Height Increase of 25 Ft. Advised by Board

Design Methods Approved — Increased Storage Needed for Control of Floods—Test Model Urged

FOLLOWING nearly two years of study on the Boulder dam project, the Colorado River Board of engineers and geologists has presented a report to Secretary Wilbur favoring an increase in the height of Boulder dam by 25 ft., approving the general procedure being followed in analyzing the stresses in the dam and urging the construction and testing of a model dam to check the reliability of the methods of stress analysis. Membership of the board consists of Major-Gen. William L. Sibert, W. D. Mead and Robert Ridgway, engineers, and Charles P. Berkey and W. J. Mead, geologists.

Reasons for the projected increase in height are given in the report as follows:

The power to be developed at Boulder dam was fixed at 550,000 firm horsepower. The board found that this power could be developed at the present time with the power storage provided, and that ordinary floods could be satisfactorily controlled. However, in the event of a great flood such as that of 1884 it would be necessary to send as much as 160,000 sec.-ft. of water down the valley in order to prevent the dam from being overtopped.

Although a flood of this magnitude has occurred only once in the last 50 years, the possibility of its recurrence is nevertheless a constant menace and the board is informed that the people of the lower valley demand that provision be made more effectively to control such unusual floods. Without encroaching upon the lower development provided for, this increased flood control can be accomplished only by increasing the height of the dam. The Bureau of Reclamation has proposed that the crest of the dam be raised 25 ft., from El. 1,207 to El. 1,232, for the purpose of providing an additional flood-control storage of 4,500,000 acre-ft. with a freeboard of 3 ft., thus making the total flood-control storage 9,500,000 acre-ft. The board approves the proposed increase in the height of the dam, and is of the opinion that this change can be made within the adopted estimate of cost.

The board emphasizes the fact that its approval of the increase in height of the proposed dam is based solely on the desirability of more effective flood control and that the development of the power should never be a factor in the control of the flood storage space in the reservoir.

New Willamette Bridge Projected

Voters of Multnomah County, Ore., in which is situated the city of Portland, will vote on May 16 on a $6,500,000 bond issue for another bridge across the Willamette River, to be known as the Fremont bridge. With its proposed location across the lower harbor it will be necessary to give this bridge sufficient horizontal and vertical clearance to satisfy shipping requirements of the port of Portland. As at present planned, the bridge will have no piers in the river and will have a vertical clearance of 205 ft. above mean water level. Six lanes of vehicular traffic on its deck are contemplated.

LOWER TALLASSEE DEVELOPMENT NEARING COMPLETION

Construction of the Lower Tallassee hydro-electric development of the Alabama Power Co. on the Tallapoosa River in Alabama should be completed this summer, according to the present schedule. The dam, 1,846 ft. long and 62 ft. high, will develop a normal head of 91 ft., generating 72,000 hp. in addition to 12,000 hp. used to replace a private power house destroyed in the development. This photograph was taken April 14.

Am.Soc.C.E. Board of Direction Acts on Many Questions

Registration and Compensation Are Considered — New Monthly Publication Established

Engineering News-Record Staff Report

WITH eighteen members present, the board of direction of the American Society of Civil Engineers in sessions prior to the spring meeting this week at Sacramento, Calif., took decisive steps in a number of progressive matters. The board decided to issue a new monthly publication in which will appear society news and some of the shorter papers now published in *Proceedings*, and which will also carry advertising matter. *Proceedings* will henceforth be published twelve times per year and *Transactions* will be continued.

The board adopted as the attitude of the society toward the desirable relationship between architects and professional engineers the resolutions passed Feb. 22 by the New York State Board of Licensing for Professional Engineers, which expressed the view that legislation affecting the operations of either profession should have due regard for pre-existing practice and activities. Authority was voted for a committee on municipal cleansing practice which is to invite the American Public Health Association, the American Medical Association, the League of American Municipalities and others to name representatives to a joint group whose purpose will be to study problems of disposal of wastes other than sewage.

Edward P. Lupfer, of Buffalo, was selected to fill the unexpired term of George H. Norton, deceased, formerly director from District 3. The area to be included in the new district recently approved by the membership is being given further study. A student chapter was authorized at the Catholic University of America at Washington, D. C. An outline of the services to be expected from professional engineers and the compensation to which they are entitled in return was adopted in the form of a final report submitted by the committee on this subject. The board also adopted and indorsed the uniform registration law for professional engineers and land surveyors recommended by the society's committee.

To the society's committee on dams was referred a request from the World Engineering Congress in Tokyo that co-operation of engineering societies throughout the world be enlisted in a comprehensive study of hydrostatic up-

lift, internal stresses and other factors affecting the safety of dams. The committee is instructed to devise, if possible, a practicable procedure in compliance with this request.

The summer meeting of the society next year will be held in Tacoma, Wash., July 8-10.

On Monday and Tuesday, preceding the civil engineers' meeting, the California Sewage Works Association held a spring conference attended by about 90 members with a program including two round-table discussions, visits to sewage-disposal plants of four types and demonstrations for the association's operators school.

Denver Improves Water System

Final plans for the extension of the water-supply system of Denver, Colo., by the construction of the Eleven Mile Canyon dam and reservoir at a cost of approximately $1,100,000 have been approved by the Board of Water Commissioners of that city. The plans are now in the hands of M. C. Hinderlider, state engineer of Colorado, for approval. The project includes the construction of a concrete dam 120 ft. high on the South Fork of the South Plate River about 20 miles above Lake Cheesman and 40 miles below Antero reservoir.

The city has just completed a new 13-mile concrete conduit costing $1,328,427 to replace two old wooden conduits built more than 40 years ago. The new pipe, with a daily capacity of 55,000,000 gal., will bring water to the Capitol Hill reservoir from Wynetka station, 2 miles west of Littleton.

California Power Merger Opposed

Creditors of the Feather River Power Co., a subsidiary of Great Western Power Company of California, have filed a petition of intervention with the California Railroad Commission in opposition to the proposed merger of Pacific Gas & Electric Co., Great Western Power Co., San Joaquin Light & Power Corp. and Midland Counties Public Service Corp. noted in our issue of April 10, p. 626. Complainants allege that there is a balance due them of approximately $783,000 on account of the construction of the Bucks Creek power project of the Feather River company, that suits for the recovery of that amount have been instituted against Great Western and Feather River companies, and that the proposed merger is not in the public interest or the interest of protestants. The petitioners ask the railroad commission to require the liquidation of their claims from the funds involved in the purchase of Feather River Power Co. by Great Western Power Co. as agent and subsidiary of Western Power Corp. Most of the petitioners are subcontractors who handled various parts of the construction of the Bucks Creek plant.

Boston Tunnel Plans Approved

Approval of preliminary plans for the construction of a single-tube vehicular tunnel between Boston and East Boston, Mass., was announced by Mayor Curley, of Boston, on April 16. Final plans and specifications will now be prepared and it is expected that the first contract will be awarded about the beginning of next year. The plans approved, originally prepared by the Boston Transit Commission, provide for a single 20-ft. tunnel for two lanes of traffic with a length of 5,443 ft. between portals. The two end sections will be constructed in open cut and the center section by the shield method under compressed air.

Public Health Bill Becomes Law

President Hoover on April 10 signed the so-called public health bill, which provides for the co-ordination of public health activities of the government. The new legislation, which makes it possible to place sanitary engineers in the Public Health Service on a commissioned status comparable with medical officers in the army and navy, was so drawn as to remove certain objections regarding its constitutionality expressed by President Coolidge in vetoing a similar bill two years ago. Co-operation with other government agencies and educational institutions engaged in research work is made possible by the detailing of public health officials for special work.

Committee Appointed to Study Bridge Legislation

The importance of bridge legislation now before Congress has been deemed sufficiently important by the American Engineering Council to justify the appointment of a special committee to study all bridge bills pending in Congress and to recommend to the Council what action, if any, should be taken with respect to them. In this action the Council is sustained by the American Society of Civil Engineers and the American Institute of Consulting Engineers. The former, through a resolution of its board of direction, has stated that the society is definitely opposed to Congressional action imposing unreasonable limitations upon the financing, design, construction and maintenance of toll bridges.

The personnel of the committee, as approved by the executive committee of the American Engineering Council, is as follows: chairman, Herbert S. Crocker, consulting engineer, Denver; V. H. Cochrane, consulting engineer, Tulsa; Prof. A. H. Fuller, Iowa State College; A. P. Greensfelder, president, Fruin-Colnon Contracting Co., St. Louis; Frank M. Gunby, associate, Charles T. Main, Inc., Boston; John Lyle Harrington, consulting engineer, Kansas City; and David B. Steinman, consulting engineer, New York City.

Hearings Start in Delaware Diversion Suit

Proceedings in a 90-day hearing on the disputed right of water diversion from the Delaware River, now being contested before Charles N. Burch, special master appointed by the U. S. Supreme Court, started April 21 at Trenton, N. J. The suit is directed against the State and city of New York by the State of New Jersey, with the State of Pennsylvania as intervener. The decision is expected to be of the highest importance in establishing definite water rights on interstate rivers.

New York State Legislation Advances Construction

Recent legislation passed by the State of New York includes the authorization of a $50,000,000 bond issue for the construction of state hospitals and prisons (to be submitted to a referendum vote); an amendment to the grade-crossing act authorizing the creation of a state debt of $26,000,000 by the sale of bonds and the appropriation of this amount for the elimination of grade crossings within New York City; another amendment giving railroad corporations the right to acquire by purchase and condemnation property required for carrying into effect the grade-crossing elimination scheme in New York City; an appropriation of $100,000 for the experimental construction of town roads by the state; a law providing for the taking over by the state of the entire expense of bridges on state and county highways; and the creation of a park commission in Essex County empowered to borrow money for park purposes. Essex County, in the northern part of the state, includes a large amount of scenic territory in the Adirondack Mountains.

Plan Large Canadian Power Plant

Immediate construction of a $23,000,000 hydro-electric development on the Abitibi River 65 miles north of Cochrane, together with the construction of a $3,500,000 transmission line to connect the new development with Sudbury, Ont., and of a 5-mile branch railroad to the site, is assured by an agreement between the Hydro-Electric Power Commission of Ontario and the Hudson Bay Power Co., a subsidiary of the Abitibi Power & Paper Co., by the terms of which the power commission will receive 100,000 hp. for a term of 40 years. Completion of the development and delivery of the power are expected in the late fall of 1931.

Ackerman Ousted as City Manager of Watertown

Dismissal of J. Walter Ackerman, who held office as city manager of Watertown, N. Y., "at the pleasure and discretion of the council," was voted April 15 by that body, after a long and bitter debate. No charges were made against Ackerman and no reasons given for the action taken. Requests made by the mayor and by citizens of the city for a public hearing on the matter were refused by the council. Mr. Ackerman declared at the council meeting that he was being removed because he had refused to discharge W. W. Kelly, corporation counsel, at the request of certain councilmen.

Mr. Ackerman went to Watertown in 1920 as superintendent of the waterworks after nearly 25 years in a similar capacity at Auburn, N. Y. He became city manager in 1923. He is a member of the American Society of Civil Engineers, the American Society of Mechanical Engineers and the American Society for Municipal Improvement, and a director of the American Water Works Association.

Tentative Program Announced for International Road Congress

Appointment of five of the seven general reporters who will present questions on the agenda of the sixth International Road Congress, to be held in Washington, D. C., next October, has been announced by Thomas H. MacDonald, secretary-general of the American organizing commission and chief of the U. S. Bureau of Public Roads. The agenda includes six questions, one of which has been divided and will be presented by two reporters. Those so far named and the subjects they will present are: Frank T. Sheets, chief highway engineer for Illinois, results obtained by the use of cement; Roy W. Crum, director, Highway Research Board, Washington, D. C., recent methods adopted for use of tar, bitumen and asphalt in road construction; E. W. James, chief, division of highway economics, U. S. Bureau of Public Roads, the construction of roads in new countries, such as colonies and undeveloped regions; Henry R. Trumbower, professor of economics, University of Wisconsin, correlation and co-ordination of highway transport with other methods of transportation; and Miller McClintock, director, Albert Russel Erskine Bureau for Street Traffic Research, Harvard University, traffic regulation, adaptation of roads to traffic in built-up areas and parking and garaging of vehicles.

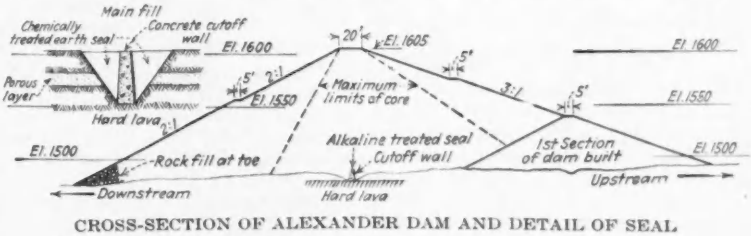
Under the rules governing the Congress the general reporters must present the question assigned to them in a paper of not more than 1,000 words. This paper is prepared following receipt of a number of papers on the subject in question from delegates to the Congress, and is in the nature of a review of the latest methods in vogue. A total of 84 papers treating of the various subjects included in the agenda has been scheduled to be submitted, and half of these already are being translated into the four languages of the Congress—German, French, English and Spanish—and will be printed and distributed.

Simultaneously with the Congress, it is expected that a private international road exhibition will be held under the auspices of the American Road Builders Association. Application blanks and other detailed information relative to the exposition may be obtained from Charles M. Upham, engineer-director of the American Road Builders Association, Washington, D. C.

Collapsed Alexander Dam a Notable Structure

Cutoff Trench Sealed by Chemically Treated Earth Fill—Unusual Design and Construction Methods

ALEXANDER dam on the Island of Kauai, Hawaii, which collapsed on March 26, as noted last week, p. 665, was a hydraulic-fill structure being built by the McBryde Sugar Co. to impound water for irrigation. The dam was located where a stream flows through a narrow canyon with impermeable side walls. As the valley floor would not support a masonry dam, an earth fill was required; it was necessary to build this by the hydraulic method because the cost of transporting machinery for any other method would have been prohibitive. The dimensions of the structure when completed were to be: height, 125 ft.; crest length, 620 ft.; maximum thickness at base, 640 ft.; total volume, 580,000 cu.yd. The valley floor consists of a porous water-bearing stratum between two more impervious strata, having a total minimum thickness of about 16 ft., all resting on hard lava rock.



CROSS-SECTION OF ALEXANDER DAM AND DETAIL OF SEAL

The first unit of the project to be built was a 1,500-kw. power house. Two 8x8-ft. tunnels fed the forebay and diverted the stream during construction. Early completion of the power plant was necessary to provide power for operating the hydraulic giants for the sluicing operations. The next unit of construction was a hydraulic-fill pioneer dam 50 ft. high which was ultimately to form the upstream part of the heel of the dam as an integral part of the structure. After the completion of the pioneer dam sluicing was started on the main dam. With the completion of the pioneer dam, seepage began to occur through the porous stratum in the valley floor. A cutoff of alkali-treated fill in a trench dug through the porous stratum was successfully used in stopping this seepage. The control method adopted was to dig a trench about on the center line of the main dam, cutting the valley floor down to the underlying hard lava and ending in the firm impervious sides of the valley. Along the center of the trench and to its full height was built a concrete wall resting on the rock. Then the trench was backfilled on both sides of the wall with the alkali-treated material, which, though slow to consolidate, was so firmly held in place by the wall and trench sides that it bore the superimposed filling of the main dam safely. The treated backfill successfully sealed the porous stratum. From 40 to 50 lb. of soda ash per ton of soil was added to the backfill material for the chemical treatment.

Two pumps, each of 1,500-g.p.m. capacity under a 300-ft. head, were employed to operate the hydraulic giants for sluicing the material into place. Black powder was used to break up the earth so that it would sluice readily without becoming too fine under the jet action, and also for pumping economy. Most of the soil was brought down from a large deposit of clay material above the dam uniformly decomposed to depths of 100 ft. or more. Because of the favorable character of the material, the use of powder and the maintenance of proper relationship between the water pressure and volume, deposition in the dam fill averaged between 12 and 21 per cent of the water pumped.

From the spoilbank the sluiced material came down wooden flumes, 2x2 ft. in cross-section, with ¼-in. steel bottom plates, on a gradient usually 3½ per cent, but sometimes as low as 3 per cent. At the dam, the flume forked into two parallel branches which formed the relatively firm upstream and downstream benches of the dam. Upon arrival at the dam the material ranged from 12-in. lumps down to fine colloidal mud.

The Alexander dam is being built by the McBryde Sugar Co., under the direction of Joel B. Cox, chief engineer. Francis E. Hance, associate chemist of the Hawaiian Sugar Planters Experiment Station, Honolulu, is in charge of the chemical soil treatments.

Delegates Named to Attend Railway Congress

Official representatives of the United States at the International Railway Congress, which will be held in Madrid, Spain, beginning May 5, 1930, have been named by President Hoover as follows: E. A. Simmons, president, Simmons-Boardman Publishing Co.; James B. Strong, president, Ramapo Ajax Corp., New York City; Walter F. Schleiter, president, Verona Tool Works, Pittsburgh; Charles H. Muchnic, consulting engineer, New York City; Bird M. Robinson, president, American Short Line Railroad Association; George R. Carr, chairman, Locomotive Firebox Co., Chicago; Harold A. Smith, publisher, *Transportation*, Los Angeles; Fred A. Poor, president, P. & M. Co., Chicago; A. S. Merz, vice-president, Standard Railway Equipment Co., New York; and Walter J. Plogsted, General Railway Signal Co., New York.

The congress will be held by the International Railway Congress Association, a permanent organization to which about 40 governments adhere and contribute annually. The United States has been a member since 1905 and contributes $800 annually.

Committee Formed to Carry On Research on Foundations

Research work on the science of foundations which is expected to occupy several years has been started by a committee on earths and foundations recently authorized by the American Society of Civil Engineers. Personnel of the committee is as follows: Lazarus White, president of Spencer, White & Prentis, Inc.; Prof. George E. Beggs, Princeton University; Prof. Melvin L. Enger, University of Illinois; Prof. Ralph J. Fogg, Lehigh University; Prof. Glennon Gilboy, Massachusetts Institute of Technology; Harry T. Immerman, of Spencer, White & Prentis, Inc.; Prof. Dmitry P. Krynine, Yale University; Frank A. Marston, of Metcalf & Eddy; George Paaswell, of the Corson Construction Co., and Prof. Charles Terzaghi, of the Technische Hochschule, Vienna, Austria.

The new committee will endeavor to secure the co-operation of owners who are about to embark on the building of large structures in neighborhoods where the underlying soils are quite compressible. In such cases conditions will be fully investigated, samples being subjected to laboratory analysis. From the data thus obtained the committee will endeavor to predict settlement of the footings of the structure and will compare these predictions with the results actually realized. A study will also be made of the effects of various types and shapes of footings. By this method it is expected to get valuable information free from the defects arising from correlating laboratory tests on a small-scale model with actual practice. Funds for the use of the committee in carrying on its research work have been appropriated by both the Engineering Foundation and the American Society of Civil Engineers.

The Business Outlook

Electric power production showed a rather sharp decline for the last week, contrary to the upward seasonal movement last year, leaving an increase over the corresponding week a year ago of only 1 per cent, the smallest so far this year, against a normal expected annual increase of 10 per cent. Except for the long-delayed final break in the copper price, the general price situation continues to improve. This strengthening, together with increased firmness in British and German commodity price indexes, encourages the conclusion that the low point of the price decline has been passed.

—The Business Week, April 23.

Cities Are Rated in Health Conservation Contest

The five winning cities in the 1929 national interchamber health conservation contest, conducted by the Chamber of Commerce of the United States with the co-operation of the American Public Health Association, have been announced. Cities showing the best record for the year in their respective classes are: Milwaukee, Wis. (Class I, more than 500,000); Syracuse, N. Y. (Class II, 100,000 to 500,000); East Orange, N. J. (Class III, 50,000 to 100,000); White Plains, N. Y. (Class IV, 20,000 to 50,000); Sidney, Ohio (Class V, under 20,000.)

Honor cities in each class are: Class I—Detroit, Mich., Philadelphia, Pa., San Francisco, Calif., Brooklyn, N. Y., Buffalo, N. Y.; Class II—New Haven, Conn., Rochester, N. Y., Cincinnati, Ohio, Yonkers, N. Y., Albany, N. Y.; Class III—Rockford, Ill., Pasadena, Calif., Racine, Wis., Harrisburg, Pa., Greensboro, N. C.; Class IV—Cumberland, Md., Alhambra, Calif., Aurora, Ill., Durham, N. C., Santa Ana, Calif.; Class V—La Salle, Ill., South Orange, N. J., Eureka, Kan., Palo Alto, Calif., Natchitoches, La.

Data furnished by the 108 competing cities, representing 30 per cent of the urban population of the United States, were confined to such fundamental and general items of public health as water supply, sewage disposal, protection of food supplies, measures for immunization and vaccination, professional visits by public health nurses and physicians in case of communicable diseases, tuberculosis and prenatal, infant and preschool care. Other items also rated were medical conferences, programs for disease prevention, life loss statistics and support for public health work by official and voluntary agencies.

Plan Standardization of Sizes for Mineral Aggregates

The U. S. Bureau of Standards is co-operating with the National Slag Association, the National Crushed Stone Association and the National Sand and Gravel Association in a joint program for the simplification of sizes of mineral aggregates used in highway construction and the standardization of screen sizes to meet these requirements. Tentative sizes have been adopted by the several groups individually for consideration at a general conference that probably will be called in June by the division of simplified practice. The standards committee of the National Sand and Gravel Association has recommended two grades of sand and five grades of gravel. The problems committee of the National Slag Association has proposed five primary sizes that represent 65 per cent of the present tonnage. The bureau has not yet received the recommendations of the National Crushed Stone Association, but it is expected that nine sizes probably will be proposed. It is the bureau's purpose to include all the sizes finally determined upon into a single consolidated list for publication.

Supreme Court Approves Indiana-Kentucky Bridge

Construction of a bridge across the Ohio River between Evansville, Ind., and Henderson, Ky., was advanced by a decree handed down April 14 by the U. S. Supreme Court in an original action between the Commonwealth of Kentucky and the State of Indiana. The two states have entered into a contract for the construction of the bridge, but action has been delayed by the action of certain citizens and taxpayers of Indiana, who instituted an action to enjoin the state officials from carrying out the contract. The Supreme Court decision forbids interference by this means.

Texas Railroad Construction Approved by I.C.C.

By transferring the Gulf, Texas & Western Railway from the Santa Fe to the Rock Island-Frisco system, the Interstate Commerce Commission has modified its railroad consolidation plan to permit the Rock Island and the Frisco to carry forward their joint construction program in northern Texas. The Frisco has been authorized to extend its line from Vernon to a connection with the Gulf, Texas & Western at Seymour, 44 miles, and the Rock Island has been authorized to build a line from Shamrock to a connection with the projected Vernon-Seymour line at Beaver Creek, 108 miles.

The commission has approved the Frisco's application to acquire control of the Gulf, Texas & Western, and both the Frisco and the Rock Island will operate over this line between Seymour and Jacksboro, thence over the

Rock Island to Forth Worth. By the new route the Frisco and the Rock Island will obtain a short direct route from southwestern Oklahoma and the Texas Panhandle to Fort Worth and Dallas. The construction cost of the Frisco line is estimated at $1,709,744 and that of the Rock Island project at $4,217,854.

The commission rejected the Burlington's plan to construct, through its subsidiary, the Fort Worth & Denver Northern, a line from Childress to Pampa, via Wellington and Shamrock, 110 miles, maintaining that construction of 110 miles of line at a cost of $4,276,580 to serve a city that is now served by two lines of the Santa Fe would not be justified.

Brief News

STRUCTURAL STEEL WORKERS in New York City need climb no more than fifteen floors to reach their work, according to a recent ruling by the Structural Steel Board of Trade. When transportation is not furnished to within fifteen stories of the derrick location, a charge will be made of one-half hour's climbing time per man. This ruling was adopted to lessen accidents caused by physical exhaustion.

PLANS FOR THE ORGANIZATION of a sewer district in a 32-square-mile area north of the city limits of Seattle, Wash., have been submitted to the county commissioners of Kings County. The plans, which involve the expenditure of several million dollars, will require a special election.

THE EIGHT-STORY FREIGHT TERMINAL and storage warehouse erected in Hoboken, N. J., by the Lackawanna Railroad at a cost of $4,000,000 will be officially opened May 1. The structure, which was described in *Engineering News-Record*, March 27, 1930, p. 519, contains 1,240,000 sq.ft. of floor space and is said to be the largest single terminal warehouse on the Atlantic seaboard. It is of reinforced-concrete and brick construction.

LOCAL GOVERNMENT IN ENGLAND will be the subject studied at the Nalgo Summer School, to be held in Keble College, Oxford, Aug. 2-16. The session will be held under the sponsorship of the National Association of Local Government Officers, Westminster.

SAN FRANCISCO has completed and opened to traffic the Bernal Ave. cut, which provides a 4,200-ft. right-of-way carrying a 42-ft. highway, an 8-ft. sidewalk, a double street-car track and a double railroad track. The cut has a bottom width of 117 ft., and required the excavation of 245,000 cu.yd. of material. It is crossed by two 40-ft. bridges with lengths of 240 and 205 ft., and is carried over a third, said to be the heaviest concrete girder bridge in the West.

WASHINGTON NOTES

By PAUL WOOTON
Washington Correspondent

Power Legislation Pending Before Senate—Rivers and Harbors Bill Reported Out

A FUNDAMENTAL change in the water-power act apparently is about to be approved by the Senate without considering the far-reaching possibilities of such legislation. The interstate commerce committee of the Senate has been giving some attention at this session to the regulation of power moving across state lines. In the course of public hearings it developed that some differences of opinion exist within the staff of the Power Commission as to the advisability of delegating accounting tasks to the accounting officers of the War, Interior and Agricultural departments. This led to the introduction of a bill by Senator Couzens, chairman of the committee, proposing a reorganization of the commission. This bill does not deal with the regulation of interstate movements of power. Without referring the bill to the executive departments concerned, it was reported favorably by the interstate commerce committee. The suggestions of Secretary Wilbur, of the Interior Department, during the hearings were overridden by the committee and apparently there is little chance that the viewpoint of the three departments will be presented in the Senate. In the House, where the administration forces are well organized, more opposition to it will be encountered.

The principal argument against the Couzens bill is that navigation, flood-control, reclamation and hydro-electric development are so related as to require handling by a co-ordinating agency rather than by an independent agency. Some of the members of the House are very determined in their opposition to the building up of new federal bureaus. In a commission independent of the three deparments they see the building up of a large organization which is certain to clash with the Forest Service, the Corps of Engineers, the Geological Survey and the Reclamation Service in the programs for the developments of rivers.

Building Codes Affect Materials

A variant has been noted by government experts which makes it difficult to compare this year's building statistics with those of preceding years. More building is obtained by the same outlay. The variant is not declining prices, but a reduction in stresses brought about by improved materials and a more accurate knowledge of the safety factor.

Building codes in many cities are being liberalized in view of increased engineering knowledge. In many sections the allowable unit stress for structural steel has been increased to 18,000 lb. Similar changes also are being permitted in lumber stresses. Requirements of other building materials are being liberalized. A survey of building codes that has been made by the Commerce Department discloses that many of these codes are outworn. It is significant, however, that a movement to bring the building codes up to date has been sweeping over the country. A recent check on the Commerce Department's survey showed that 200 cities are preparing to or already have amended their building codes.

Chicago Pays Costs

On April 21 the United States Supreme Court entered its formal decree in the Chicago diversion case. This decree was entered to carry into effect the conclusions set forth in the opinion of the court announced April 14, and given in detail on pp. 696-697 of this issue. The court ordered that costs be taxed against the defendants. Compensation of the special master, Charles Evans Hughes, now Chief Justice, was fixed by the court at $30,000 in addition to $2,775.95 which was required for expenses.

Power License Granted

A license has been issued to the Safe Harbor Water Power Corporation covering its large development on the Susquehanna at Safe Harbor, Pa. The Federal Power Commission declines to insert a condition in the license which would require the corporation to provide a crossing over the river. The corporation, however, has promised to provide half of the money required to finance the construction of a bridge in case a responsible toll bridge concern will provide the other half of the money needed.

After failing to secure any assistance from the public service commission of their state, local interests in favor of the bridge took their case to the federal commission. The investigation made on behalf of the commission indicated that a bridge at that point would be an important convenience for the people of York and Lancaster counties, but no serious effort to secure a bridge had been made previously. There is not even a ferry in operation over that part of the stream. Since the power dam does not destroy any crossing or make it more difficult to provide a crossing for vehicular traffic, no ground for the claim is seen. The investigation showed further that a site below the dam offers a more desirable project than the construction of a roadway on the face of the dam. There is an island a short distance below the dam site. By building independent structures across the two channels and construction of a roadway on the island itself, a crossing could be provided at a cost of $1,000,000. The right is given in the license for the state, the county or other responsible interests to construct a bridge on the dam, or across properties of the company. The mechanical equipment on the crown of the dam would not permit its use for a roadway, but a roadway on the face of the dam would in no way interfere with its operation. At present there are no improved roads leading to

the river in the area occupied by the project.

The Safe Harbor Corporation had anticipated the issuance of the license and had all of its materials on the ground ready to start construction work. In fact, some of the construction work began before the actual issuance of the license.

$112,000,000 for Rivers and Harbors

Projects to a total value of $112,000,000 are authorized in the general rivers and harbors bill reported to the House on April 21. It is believed that the amount authorized has been sufficiently cut down to meet the President's approval. Since a large part of the work is in the nature of surveys which are not intended to be made for the next two or three years, the expenditures required will not conflict with the present financial program of the government.

Projects authorized include the principal Atlantic, Gulf and Pacific coast harbors and various intracoastal waterways. In addition a great amount of new work is authorized on the inland waterways system. This takes in the upper Mississippi and the Missouri and permits the nationalization of the Lakes-to-the-Gulf waterway. Other projects are carried in the bill which will bring about further improvement of harbors and channels on the Great Lakes. The bill also provides for a large number of preliminary examinations and surveys. No great opposition is expected to be raised against the measure in either the House or the Senate.

Personal Notes

JOHN F. COLEMAN, of New Orleans, president of the American Society of Civil Engineers, has recently accepted membership on American Engineering Council's committee on flood control.

ESTIL A. GAST, of the Gast Construction Co., of Warsaw, Ind., who has been active in civic work for several years, has been elected president of the Warsaw Chamber of Commerce.

W. A. SHEPPARD has been appointed purchasing agent for the city of Vancouver, B. C.

Major JOHN C. KINGMAN, formerly district engineer at Milwaukee, has been ordered to duty in the office of the Chief of Engineers at Washington. Major WILLIAM A. SNOW has been dispatched to St. Louis for duty with the St. Louis engineer district. Before leaving for this new station he filled the post of district engineer, Wilmington, N. C.

WILLIAM W. MACON has been appointed editor-in-chief of *The Iron Age*, succeeding Alvin I. Findley, who has held that position during most of the 25 years he has been associated with the publication. Mr. Findley will continue to serve as editor emeritus. Mr. Macon has been connected with the editorial staff of *The Iron Age* for nineteen years, having been managing editor for the past twelve years.

THOMAS S. BURNS, who for the past seven years has been hydro-electric engineer with the Power Corporation of New York and the Northern New York Utilities, Inc., associated with W. P. Creager at Watertown, N. Y., until the absorption of these two power companies into the Niagara Hudson Power Corporation and the consequent disbanding of their engineering organizations, has been appointed senior hydro-electric engineer in the United States Engineer Office. Mr. Burns will be engaged in studies of water-power resources, markets for hydro-electric energy, combinations of navigation improvement and flood relief with hydro-electric power development in the Pittsburgh district.

NORMAN BEREFORD MCLEAN, formerly assistant chief engineer of the St. Lawrence Ship Channel, has been promoted to the position of chief engineer of that work.

ROBERT W. RANKIN, superintendent of maintenance of Division No. 3 of the Ohio Highway Commission, has resigned his position, effective May 1, to become head of the Mansfield Asphalt Paving Co., of Mansfield, Ohio. He had been connected with the highway commission for eight years.

JOSEPH C. GILBERT, who for the past two years has been employed by the United Engineers & Constructors as assistant superintendent and job engineer on the construction of steam power plants in Texas, is now hydraulic engineer for Winston & Co. on the construction of the Cobble Mountain hydraulic-fill dam for the city of Springfield (Mass.) water-supply system.

Society Calendar

AMERICAN SOCIETY FOR TESTING MATERIALS, Philadelphia; annual meeting, Atlantic City, N. J., June 23-27.

AMERICAN SOCIETY OF CIVIL ENGINEERS, New York; annual convention, Cleveland, Ohio, July 9-11.

AMERICAN WATER WORKS ASSOCIATION, New York; annual meeting, St. Louis, Mo., June 2-6.

INTERNATIONAL CONGRESS OF BUILDING AND PUBLIC WORKS, London; fifth congress, London, England, May 26-30.

INTERNATIONAL RAILWAY CONGRESS, Madrid, Spain, May 5-15. American vice-president, T. S. Morgan, 119 West 42d St., New York.

WORLD POWER CONFERENCE, second plenary meeting, Berlin, Germany, June 16-25. American secretary, O. C. Merrill, Washington, D. C.

CLAY PRODUCTS INSTITUTE at its recent meeting in Washington, D. C., elected officers as follows: president, Prof. T. R. Lawson, Rensselaer Polytechnic Institute; vice-presidents, Anson Marston, Iowa State University, and D. E. Parsons, U. S. Bureau of Standards; secretary, J. W. McBurney, U. S. Bureau of Standards.

FLORIDA SECTION, American Water Works Association, held its fourth annual meeting at Gainesville April 10-11. During the two-day session nineteen papers were presented before an attendance of 125. Officers elected were: chairman, Prof. A. P. Black, University of Florida; vice-chairman, F. W. Lane, St. Petersburg; secretary-treasurer, E. L. Filby, Jacksonville (re-elected); representative to the national council, A. P. Michaels, Orlando. A two-day short course in water and sewage treatment which preceded the convention was so successful that it was decided to make this an annual event and to extend it to cover four or five days. An attendance of 69 was registered at the school.

NATIONAL ASSOCIATION OF RAILROAD TIE PRODUCERS will hold its twelfth annual meeting at Memphis, Tenn., on April 29 to May 1. Papers on ties and timber treatment by railroad engineers and representatives of the lumber industry are on the program. Roy M. Edmonds, St. Louis, is secretary.

NATIONAL SAND AND GRAVEL ASSOCIATION board of directors will meet May 14-15 at Milwaukee, Wis., to select the city in which the 1931 annual convention will be held and to make arrangements for a trade practice conference to be held in connection therewith. The subject of uniform cost accounting will also be taken up.

NEW YORK SOCIETY OF THE PANAMA CANAL will hold its sixth annual banquet at the Hotel Astor, New York City, on May 3.

NEW YORK STATE SOCIETY OF PROFESSIONAL ENGINEERS AND LAND SURVEYORS will hold its third annual convention in New York City April 30. Joseph A. Nichols, Grand Central Terminal, New York, is chairman of the convention committee.

SOUTHEASTERN SECTION, American Water Works Association, has elected officers as follows: chairman, H. F. Wiedman, Atlanta; secretary-treasurer, W. H. Weid, Atlanta.

Obituary

J. E. BONNELL, of Tacoma, Wash., for 42 years a contractor in that city, died recently after a brief illness. Among his many construction projects was the building of Fort Seward, Alaska, 25 years ago.

DOUGLAS SPRAGUE, of Mount Vernon, N. Y., for 30 years a consulting engineer in New York City, died on April 17. Mr. Sprague was born in Canada 69 years ago.

CHARLES A. WAGNER, of San Francisco, Calif., a structural engineer, was found dead in a canyon 2 miles west of Woodside, Calif., on April 15 with a revolver clutched in one hand. He had been missing from his home for four days and it is believed that recent financial losses drove him to suicide. He was 39 years old.

CHARLES AUGUSTUS VAN KEUREN, chief engineer of the Department of Streets and Public Improvements of Jersey City, N. J., since 1898, died on April 21. He was 78 years old. Mr. Van Keuren, before locating in Jersey City, had been connected with the transportation department of the Pennsylvania Railroad and had been assistant engineer of the Buffalo division of the West Shore Railroad. From 1884 to 1898 he was assistant engineer of the municipality of Jersey City. He was a member of the American Society of Civil Engineers.

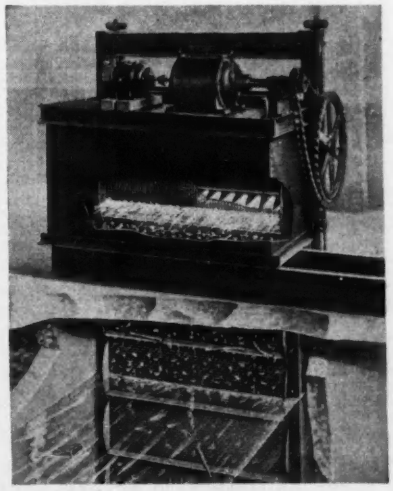
Construction Equipment and Materials

Large Rock Crushers Shipped to India

The largest crushing installation ever produced in the United Kingdom has recently been dispatched to the Cauvery dam, India. It was made in Sheffield and comprises three electrically driven plants, each capable of handling from 135 to 146 tons of rock per hour. There are three jaw-type primary crushers, with feed openings 54x42 in.; eighteen 24x13-in. jaw-type secondary crushers; and six disk crushers 36 in. in diameter and 20 ft. long, together with the necessary elevators, conveyors and other accessories. Wearing parts of the crushers are made entirely of manganese steel. Each of the large primary crushers weighs about 112 tons, the largest ever constructed in Britain.

Traveling Water Screen Seals All Bypass Openings

Several new features are embodied in a traveling water screen developed by the Chain Belt Co., Milwaukee, Wis., which effectively seals all openings which might bypass debris. The screen is constructed of rectangular baskets which hold the screen cloth and are in turn carried by two strands of hardened steel roller chain. This operates over head and foot sprockets. As the submerged screen surface becomes clogged, the screen is revolved and the refuse is lifted from the intake by the upward travel of the baskets and automatically removed from the screen by means of a spray which washes the refuse into a trough for disposal. The foot wheel is so designed as to permit the use of a new extended track shoe which engages the roller at the exact instant it leaves the wheel. Thus there is no intervening space in which the roller can weave inward, causing openings between the ends of the baskets and the frame of the screen.



DETAILS OF TRAVELING WATER SCREEN

Character of Confined Air Shown by Testing Device

Dangerous atmospheric conditions in confined spaces, such as sewers and manholes, are revealed by a portable gas detector developed by G. W. Jones, of the U. S. Bureau of Mines, and manufactured by Mine Safety Appliances Co., Pittsburgh, Pa. This is said to be the only instrument for practical field use which shows either the presence of an explosive gas or a deficiency in oxygen. It consists essentially of a bomb in which a sparkplug is inserted and to which a pressure gage is attached. Provision is made for the enrichment of a sample of the suspected air by means of measured amounts of propane and for the ignition of the mixture. The entire assembly is mounted upon a mahogany-finished wooden stand.

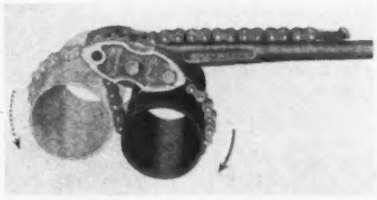
TESTING MANHOLE FOR DANGEROUS ATMOSPHERIC CONDITIONS

In operation, the sample to be tested is forced into the apparatus and ignited. If an explosion occurs, this is shown by an increase in the gage reading. When no explosion occurs, the gas, if present, is not in the right proportion to form an explosive mixture. By extensively enriching the sample by means of injections of propane, it is possible to detect the presence of explosive gases in quantities below the lower explosive limit. If there is no initial explosion and no later explosion after the addition of propane, the original sample consists either of an inert atmosphere deficient in oxygen, or of explosive gas concentrated above the upper explosive limit. To determine which of these conditions exists, another sample is taken into the apparatus and successively diluted with measured quantities of air, an attempt at ignition being made with each addition.

A simpler form of detector which is used in testing for carbon monoxide gas only is also manufactured by this company. This consists of an ampoule which is crushed and exposed to the suspected atmosphere. Carbon monoxide, if present, will change the color of the ampoule, and comparison with a standard color chart will give the approximate concentration of the gas.

Reversible Action Feature of Chain Pipe Tongs

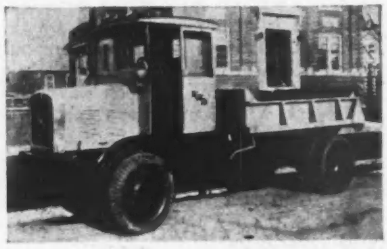
Simplicity in operation is the feature of a new type of chain pipe tongs, known as the Vulcan Boll-Weevil, which has been developed by J. H. Williams & Co., Buffalo, N. Y. This tool, made in four sizes for pipe from ¾ to 12 in., makes it unnecessary to hold the tongs up against a pipe from below until the chain can be wrapped around and hooked. Instead, the tool is simply laid on top of the pipe and the chain hooked around from above. Once in position, the pipe can be turned either way. For tightening, the tongs are slid forward so that the rear end of the jaws engage the pipe (see dark pipe in illustration), which is then turned by pushing down on the handle. When the joint is to be loosened the tongs are pulled back, engaging the forward teeth (as shown by the phantom pipe) and the handle is pulled up. The arc of the jaws and the shape of the teeth are designed to give a positive bite. Longer life is insured by making the jaws reversible, so that when the teeth first in use wear, the jaws can be turned end for end, doubling the life of the tool.



REVERSIBLE PIPE TONGS

Medium-Capacity Truck With Four Wheel Traction

With a rating of 2½ tons, the new model HH-6 truck announced by the Four Wheel Drive Auto Co., Clintonville, Wis., provides an unusually flexible unit for various hauling conditions. The six-cylinder 3½x4¼-in. motor with seven-bearing crankshaft develops 66 hp. at 2,000 r.p.m. Adequate lubrication of this engine on steep grades is insured by a special oil sump designed to maintain proper oil level under all road conditions. Drive is through a dry clutch with eight sets of disks, then through a seven-speed transmission and sub-transmission to the front and rear axles. The usual center differential utilized in all FWD trucks is used, together with the mechanical lock to insure traction on all four wheels on



2½-TON TRUCK WITH DUMP BODY

slippery roads. Both front and rear axles are of the full-floating type with bevel gears. The service brake, located on the rear of the sub-transmission, operates through all four wheels, and the emergency, or hand brake, is of the internal expanding type on rear wheels only. Standard equipment includes electric starting and lighting, steel spoke wheels with 36x8-in. pneumatic tires, air cleaner and oil filter.

New Publications

Grading Equipment—Dump carts, scrapers, rooters, sheep's-foot rollers, bulldozers and power units for their control are described in "A Small Book Featuring Some Big Machinery," issued by LE TOURNEAU MANUFACTURING CO., Stockton, Calif.

Warning Signals—Neon lights for the protection of railway grade crossings are being introduced by INTERNATIONAL EQUIPMENTS, INC., New York City. Advantages of this type of signal and results of tests made on several Canadian installations are given in a 16-p. illustrated bulletin recently issued.

Hydrogen-Ion Control—Theory, methods of operation and applications of the hydrogen-ion control are given in great detail in the sixth edition of "The A.B.C. of Hydrogen-Ion Control," published by LA MOTT CHEMICAL PRODUCTS CO., Baltimore, Md. The book contains 133 pages and many illustrations.

Cast Stone—Characteristics, advantages, methods of manufacture and tentative standard specifications for cast stone, a building stone molded from special prepared concrete in which the aggregate is selected for durability and appearance, are given in a 28-p. booklet issued by the CAST STONE INSTITUTE, Chicago, Ill., which is profusely illustrated to show applications of the process.

Road Maintenance Equipment—LITTLEFORD BROS., Cincinnati, Ohio, have issued two 32-p. booklets describing their products. One of these is a full-size catalog describing asphalt kettles, heaters and miscellaneous contractors' equipment, the other a pocket-size booklet in which the text is greatly condensed. Both publications are illustrated.

Light Railways — KOPPEL INDUSTRIAL CAR & EQUIPMENT CO., Koppel, Pa., has issued bulletin 62 describing standard quarry cars, track and track equipment.

Clutches — Structural features of the Magee-Pfeiffer clutch are described in a 16-p. illustrated bulletin of the MAGEE-PFEIFFER CO., Chicago, Ill.

Wagons and Trailers—Dump wagons and trailers in capacities up to 20 cu.yd., with both wheel and crawler mountings, are illustrated and described in a 16-p. catalog T-30 issued by A. STREICH & BRO. CO., Oshkosh, Wis.

Excavating Machinery—Ground pressure data on Northwest crawler equipped shovels, cranes and draglines are given in a recent publication of the NORTHWEST ENGINEERING CO., Chicago, Ill.

Pipe—Many interesting illustrations showing typical installations of Naylor Spiral-weld steel pipe are given in a 46-p. bulletin 30-1 issued by the NAYLOR PIPE CO., Chicago, Ill. Advantages of this kind of pipe are discussed briefly in the text.

Drill Steel—General information and detailed instructions in regard to the heating, forging and tempering of drill steel are given in a 48-p. illustrated circular 72-K issued by the SULLIVAN MACHINERY CO., Chicago, Ill. The publication is well described by its title, "A Handbook of Rock Drill Steel," for it answers practically every question on this subject which can arise, varying from the layout of a model steel-sharpening shop to the proper heat treatment of steel for best results.

Welding Rod—Over 40 different types of welding rods, for use in every phase of welding, are conveniently listed and described in a recent bulletin of the FUSION WELDING CORP., Chicago, Ill. General information such as standard rod sizes and lengths, packing and other details is also covered.

Oil Storage Tanks—"Stopping Evaporation With the Wiggins Breather Roof" is the title of a 22-p. illustrated bulletin of the CHICAGO BRIDGE & IRON WORKS, Chicago, Ill., which gives detailed information on an oil storage tank roof which prevents evaporation by flexing up and down instead of venting vapor out of the tank. A report of the U. S. Bureau of Mines giving specific data on gravity savings is also reprinted in full.

Traffic Control — Personnel, scope and facilities of the AUTOMATIC SIGNAL CORP., New Haven, Conn., are revealed in a 15-p. illustrated booklet recently issued.

Instruments—Remote control instruments for indicating, recording and controlling flows, pressures, liquid levels and positions are described in a 32-p. illustrated bulletin issued by the BROWN INSTRUMENT CO., Philadelphia, Pa.

Concrete Admixture — "Celite for Construction" has been issued in a revised and enlarged edition containing new material and photographs by the JOHNS-MANVILLE CORP., New York City.

Chain Drives—Information necessary to design, install and maintain Morse silent chain drives is contained in a 104-p. data book published by the MORSE CHAIN CO., Ithaca, N. Y. Speed reducers and flexible couplings are also covered.

Costs and Contracts

E. N.-R. Index Numbers

Cost			Volume	
Apr. 1,	1930	207.12	March,	1930	408
Mar. 1,	1930	206.80	February,	1930	204
Apr. 1,	1929	203.40	March,	1929	382
Average,	1929	207.02	Average,	1929	317
Average,	1928	206.78	Average,	1928	287
1913.....		100.00	1913.....		100

This Week's Contracts

Heavy construction contracts, reported by *Engineering News-Record* in the week of April 24, with some comparisons, total as follows:

(In Thousands of Dollars)

	Apr. 24, 1930	Average Preceding Four Weeks 1930	1929
Buildings:			
Industrial.....	$4,783	$9,389	$8,751
Other.....	70,368	43,151	43,334
Streets and roads...	18,528	11,596	7,356
Other eng. constr.....	18,195	15,586	18,882
Total.....	$111,874	$79,723	$78,324

Total, all classes, Jan. 1 to Apr. 24:

1930.....	$1,160,688
1929.....	1,438,115

CONTRACTS AWARDED IN FIRST FOUR MONTHS

(Millions of Dollars)

	1930	1929	Per Cent Change
Public:			
Water-works.....	17	13	+ 30
Sewers.....	24	25	— 4
Bridges.....	39	19	+105
Buildings.....	103	107	— 3
Roads.....	159	105	+ 51
Buildings:			
Industrial.....	125	191	— 34
Other.....	522	759	— 31
Total public wks.	403	364	+ 10
Electric power.....	51	26	+ 96
Total.....	454	390	+ 16
Total engineering....	1,160	1,438	— 18

Business Notes

NATIONAL COMMITTEE ON WOOD UTILIZATION of the U. S. Department of Commerce will hold its annual meeting in Washington, D. C., May 2. The principal object of the meeting will be to consider how the committee can best function in carrying out the various projects it now has under way. These include the introduction of the Scandinavian gang sawing system, the stocking of chemically treated wood by retail lumber yards and promotion of the use of small dimension stock in the manufacturing field.

THE SIMPLIFIED PRACTICE RECOMMENDATION regarding vitrified paving brick has been reaffirmed without change for a period of one year. A survey conducted prior to the revision meeting indicated the degree of adherence to the recommendation to be approximately 87.8 per cent of the industry.

TRADE PRACTICE RULES governing the crushed stone and metal lath industries have been approved by the Federal Trade Commission. The former were adopted at a conference held in Cincinnati, Ohio, Jan. 23, 1930, the latter in Washington on June 27, 1929.

DOMINION STEEL & COAL CORP., a new organization chartered in Nova Scotia, will take over the physical assets of the British Empire Steel Corp., the Dominion Steel Corp., Ltd., and the Dominion Iron & Steel Corp., Ltd. The consolidated company will have assets of more than $50,000,000. Directors of all three companies concerned have approved the merger, which will be submitted to shareholders for their authorization.

WESTINGHOUSE ELECTRIC & MANUFACTURING CO., East Pittsburgh, Pa., has placed W. S. Rugg, vice-president in charge of engineering, also in charge of sales activities. Mr. Rugg takes over the activities of Edward D. Kilburn, vice-president and general sales manager, whose resignation was accepted April 16. S. M. Kintner, director of the Westinghouse Research Laboratory, has been made assistant vice-president and will assume engineering department duties under the direction of Mr. Rugg.

SOULÉ STEEL CO., Los Angeles, Calif., has purchased the United States Metal Products Co., San Francisco, manufacturer of steel windows and doors. No change will be made in personnel, and marketing arrangements will continue as at present.

RELIANCE ELECTRIC & ENGINEERING CO., Cleveland, Ohio, has appointed Ralph R. Newquist sales engineer of its Chicago office.

PARADON MANUFACTURING CO., Arlington, N. J., will be represented in Minnesota, North Dakota, South Dakota and northern Wisconsin by Gerald Standish, who will be located in Minneapolis.

PITTSBURGH TESTING LABORATORIES, Pittsburgh, Pa., has appointed M. L. Carr staff engineer. Mr. Carr is a graduate of the University of Illinois and has been connected with the Underwriters Laboratories, the Safe Cabinet Co. and the Barrington Associates, New York City.

BYRON JACKSON CO., Berkeley, Calif., is now occupying a new plant constructed for the deepwell turbine unit.

REPUBLIC RESEARCH CORP. has been incorporated as a unit of the new Republic Steel Corp. to handle specialized research. Headquarters will be at Massillon, Ohio. F. J. Griffiths, former chairman of the Central Alloy Steel Corp., will head the new unit.

STEEL & TUBES, INC., Cleveland, Ohio, announces the removal of the general sales department of the electrical division from Brooklyn, N. Y., to Cleveland.

TIMKEN ROLLER BEARING CO., Canton, Ohio, has elected the following officers: chairman, H. H. Timken; president, M. T. Lothrop; vice-presidents, W. R. Timken, J. G. Obermier, J. W. Spray, H. J. Porter, T. V. Buckwalter, L. M. Klinedinst; secretary-treasurer, R. C. Brower.

C. J. TAGLIABUE MANUFACTURING CO., Brooklyn, N. Y., has purchased a five-story concrete fireproof factory building which will be occupied about July 1. The new plant will more than double present facilities of the company.

JAMES VERNER SCAIFE, president of the Wm. B. Scaife & Sons Co., Pittsburgh, Pa., died on March 31.

JOSEPH KATZENSTEIN, of the New York sales office of the Chicago Pneumatic Tool Co., died suddenly of heart disease April 2. He was born at Saratoga, N. Y., Aug. 21, 1877.

Unit Prices From Current Construction Bids

Newark Bridge of Nine Through Girder Spans, Concrete Viaducts and Approach Fills

THE contract for the Haynes Ave. highway bridge in Newark, N. J., was awarded in February, 1930, by the Department of Public Affairs to J. Rich Steers, Inc., for $885,439. It consists of nine through plate-girder spans 102 ft. 8 in. each, and 230 ft. of reinforced-concrete viaduct structure with approach fills. The girders for the main span (Fig. 2) are 9½ ft. back to back of flange angles and are placed 45 ft. apart, giving a clear roadway of 40 ft. Sidewalks 12 ft. wide are cantilevered outside the main girders.

Floor construction consists of 36-in. 250-lb. rolled beams spaced 8 ft. 2 in. transversely. The floor is an 8½-in. concrete slab reinforced top and bottom with 2½-in. wearing surface.

Features Affecting Cost—Two features affect both cost and bidding: (1) necessity of maintaining traffic on an existing bridge, finally to be removed; (2) the fact that the bridge crosses 36 railway tracks. Item 14 for maintenance of traffic and removal of the present Haynes Ave. bridge calls for the shifting of the present structure to clear the new construction. This shifting will be approximately 22 ft. in a horizontal direction. The present structure is composed of five steel pony-truss spans of from 130 ft. to 140 ft. and a section of timber trestle. The contractor is required to shift these trusses, provide new piers for them and at the completion of the job to remove the structure. The old bridge must be kept open to traffic except for a period of two weeks, which is permitted for shifting the bridge. The fact that this bridge crosses the Waverly yard of the Pennsylvania Railroad at a point where there are 36 tracks, including four main-line tracks, adds to the complication of the erection problem. The lowest bid for this item was $74,000; the average of the three bidders, $89,000; the engineer's estimate, $60,000.

Concrete—The largest item was the concrete, amounting to 31 per cent of the low bid. Items *17a, b, c* are for concrete in place, not including cement, which is a separate item (16). For this reason the exact mix is not specified, flexibility being permitted under the contract. Classes 1 and 2 concrete are approximately 1 : 2 : 4. The former is for retaining walls, piers and abutments. Although these are reinforced, this concrete is in general mass construction. Class 2 is used for girder incasement, fence posts, stairs, and lamp-post bases. Pea gravel is permitted for coarse aggregate. There are no minimum strength requirements for these two classes. Class 3 (1 : 1½ : 3) is for roadway and sidewalk slabs. Minimum strength of 3,500 lb. at 28 days is required.

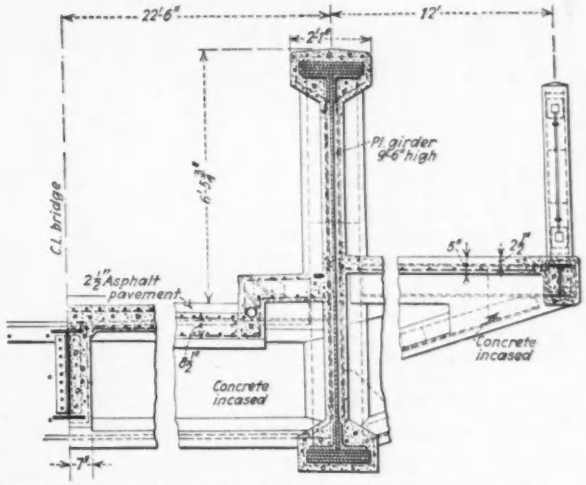


FIG. 1—HALF CROSS-SECTION OF PLATE-GIRDER SPAN

Other Items—Class A fill (*7a*) is selected and compacted fill, as contrasted with fill that is merely dumped.

The waterproofing is asphalt mastic with a priming coat applied to the back of the retaining walls without membrane.

Temporary paving (*74b*) consists of either second-hand granite or traprock block, laid in sand cushion or penetration

Item	Description	Unit	Quantity	J. Rich Steers, New York Price	J. Rich Steers, New York Amount	Johnson, Drake & Piper, Freeport, N. Y. Price	Frederick Snare, New York Price	Engineer Price
1	Structure excavation	Cu.yd.	9,000	$4.00	$36,000.00	$3.50	$5.00	$4.00
2	Trench excavation	Cu.yd.	700	3.00	2,100.00	1.50	5.00	7.00
7a	Earth and rock fill	Cu.yd.	12,000	0.40	4,800.00	0.40	0.50	0.50
9c	Temporary timber	M.b.m.	25	87.00	2,175.00	75.00	90.00	100.00
14	Maintenance of traffic and removal of present bridge	Lump	1	74,000.00	74,000.00	102,000.00	91,000.00	60,000.00
15d	Concrete piles 20 ft. or less in length	Each	1,250	30.00	37,500.00	56.00	66.00	50.00
15e	Concrete piles over 20 ft. and less than 30 ft.	Lin.ft.	4,500	2.00	9,000.00	2.80	3.30	2.50
15f	Concrete piles over 30 ft. in length	Lin.ft.	300	2.00	600.00	3.20	3.90	2.50
16	Cement used in concrete or in mortar	Barrel	16,000	2.75	44,000.00	2.65	2.50	2.60
17a	Class 1 concrete exclusive of cement—piers and walls	Cu.yd.	5,700	17.00	96,900.00	16.40	16.00	18.00
17b	Class 2 concrete exclusive of cement—incasement	Cu.yd.	1,340	54.25	72,695.00	60.00	55.00	76.00
17c	Class 3 concrete exclusive of cement—slabs	Cu.yd.	2,900	36.00	104,400.00	25.00	28.00	23.00
20	Sand use in mortar	Cu.yd.	110	6.00	660.00	5.00	10.00	10.00
24	Brick masonry	Cu.yd.	25	45.00	1,125.00	30.00	35.00	40.00
29	Waterproofing without membrane	Sq.yd.	2,500	0.50	1,250.00	0.60	1.20	0.50
35	Structural and cast steel	Ton	2,050	116.00	237,800.00	110.00	114.00	125.00
37	Miscellaneous steel	Lb.	77,000	0.10	7,700.00	0.07	0.17	0.15
38	Reinforcing steel	Ton	690	120.00	82,800.00	110.00	100.00	120.00
39	Wire mesh or expanded metal	Ton	37	270.00	9,990.00	174.00	240.00	250.00
50	Miscellaneous iron castings	Ton	43	100.00	4,300.00	99.00	180.00	200.00
55	Wrought-iron pipe with fittings	Ton	3.5	575.00	2,012.50	212.00	340.00	200.00
60	Cast-iron pipe, bell and spigot, straight	Ton	30	100.00	3,000.00	66.00	180.00	150.00
61	Cast-iron pipe, bell and spigot, specials	Ton	3	200.00	600.00	195.00	340.00	250.00
72	New granite curb	Lin.ft.	520	2.50	1,300.00	3.00	4.50	2.50
74a	New sheet asphalt pavement	Sq.yd.	5,300	1.85	9,805.00	2.10	2.20	2.25
74b	Temporary pavement	Sq.yd.	7,000	1.70	11,900.00	1.75	1.20	1.25
75	Temporary sidewalk	Sq.ft.	12,500	0.08	1,000.00	0.25	0.10	0.15
80h	4-in. vitrified tile pipe	Lin.ft.	350	1.10	385.00	0.30	1.00	0.80
80q	12-in. vitrified tile pipe	Lin.ft.	490	1.54	754.60	0.85	2.20	1.00
80k	18-in. vitrified tile pipe	Lin.ft.	750	2.23	1,672.50	1.75	3.30	1.50
97d	Type C fence	Lin.ft.	3,600	4.50	16,200.00	4.00	5.50	7.00
97e	Type D fence	Lin.ft.	440	2.00	880.00	3.00	3.50	5.75
100h	2½-in. steel conduits (gal.)	Lin.ft.	3,200	0.96	3,072.00	0.70	1.50	1.10
115	Electric light standards	Each	30	62.50	1,875.00	95.00	120.00	70.00
	Totals				$885,439.40	$898,532.75	$936,476.00	$934,430.00

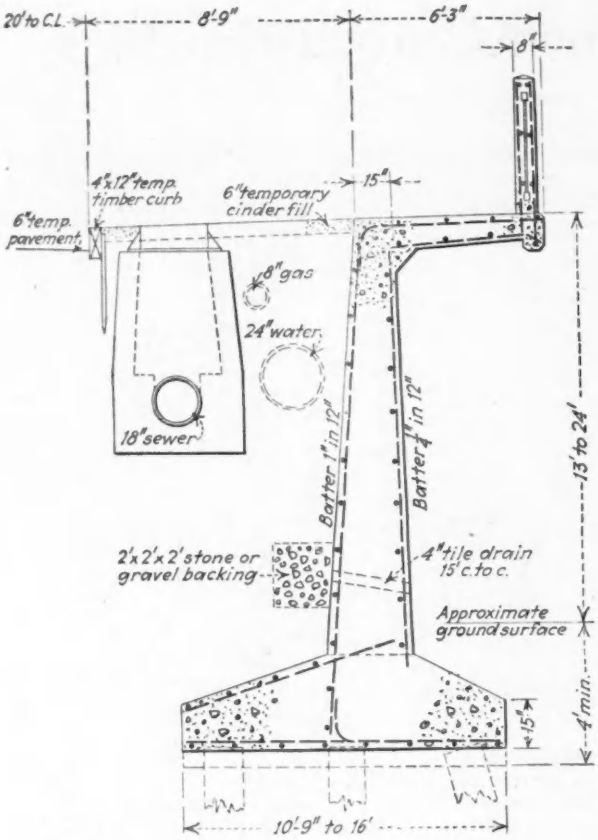


FIG. 2—TYPICAL SECTION OF CANTILEVER RETAINING WALL

macadam 6 in. thick, at the option of the contractor. This pavement is to be laid on fills until they are sufficiently consolidated for permanent paving. Temporary sidewalk (75) consists of a 6-in. layer of cinders.

Excavation of about 500 cu.yd. will be required in connection with placing the 12- and 18-in. vitrified tile pipe, but not for the 4-in. tile pipe, which is used for weepholes.

Type C fence (*97d*) consists of 8x12-in. reinforced-concrete posts 8 ft. 3 in. centers, connected by a steel fence of 3x2-in. rectangular steel top and bottom members with $\frac{5}{8}$-in. square steel pickets 4 in. centers between top and bottom rail, which are $3\frac{1}{2}$ ft. apart. Type D fence is a two-rail galvanized-iron pipe fence, top rail and post being 3 in. in diameter, the lower $2\frac{1}{2}$ in. The posts are 6 ft. centers, expansion bolted at the base.

James W. Costello is chief engineer of the Department of Public Affairs; Ralph Smillie is transit engineer.

Cost of a Boardwalk on Long Island

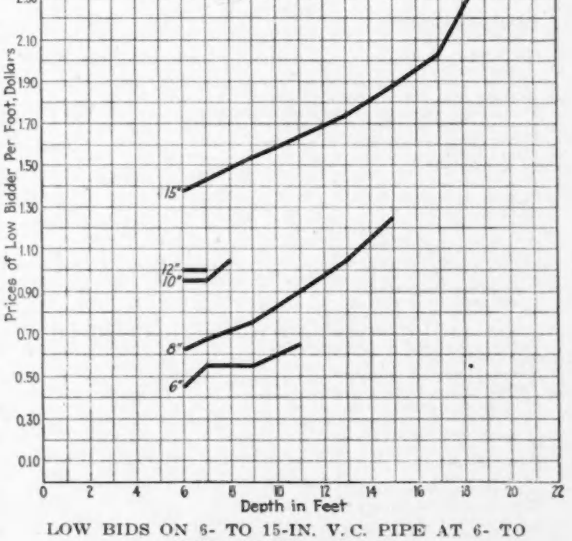
LUMP sum bids for a boardwalk at Jones Beach State Park, N. Y., were received March 28, 1930, by the Long Island State Park Commission. The boardwalk is 40 ft. wide by 3,500 ft. long, of wood piles, wood deck and ship rails. Six open pavilions are included. The structural members are Western fir and the decking is fir flooring. Seventeen bids were received for both untreated and treated lumber. The cost of treating averages 14 per cent more than the untreated bids. The Walman salt treatment is used, which comprises 4 per cent salt solution for fire retarding and 2 per cent fluoride phenol for protection against fungus. The method is vacuum heating in retorts at yard or mill, not at job. The lowest three bidders are: (A) Graves-Quinn Corp., Grand Central Bldg. (contract for treated); (B) Long Island Dredging Corp., Bennet Pl., Lindenhurst; (C) A. N. Spooner & Son, Inc., Pier 11, North River, New York. The bids:

	Untreated	Treated	Per Cent for Treating
A	$147,850	$172,700	17
B	156,900	176,900	13
C	171,400	191,300	12
Average 17	$189,000	$215,000	14

Sanitary Sewers at Dallas, Tex.

CONTRACT 7 for sanitary sewers in Dallas was awarded in March for $39,768. This bid was 22 per cent under the average of the five received. The accompanying tabulation lists the unit prices of the lowest three bidders: (A) Kirkwood, Wharton & Lee, San Antonio; (B) Dozier Construction Co., Austin; (C) Central Contracting Co., Dallas.

		A	B	C
1,000 cu.yd. rock excav.		$4.00	$4.00	$4.95
6-in. vitr. clay pipe	Depth, Ft.			
2,160 lin.ft.	0– 6	0.45	0.60	0.61
4,220 lin.ft.	6– 8	0.55	0.70	0.68
1,560 lin.ft.	8–10	0.55	0.80	0.85
135 lin.ft.	10–12	0.65	0.95	1.00
8-in.				
4,000 lin.ft.	0– 6	0.62	0.65	0.77
4,650 lin.ft.	6– 8	0.67	0.75	0.84
3,500 lin.ft.	8–10	0.75	0.85	1.08
1,550 lin.ft.	10–12	0.90	1.10	1.17
750 lin.ft.	12–14	1.05	1.30	1.22
330 lin.ft.	14–16	1.25	1.65	1.50
10-in.				
50 lin.ft.	0– 6	0.95	0.80	0.98
375 lin.ft.	6– 8	0.95	0.90	1.09
150 lin.ft.	8–10	1.05	1.15	1.27
12-in.				
425 lin.ft.	6– 8	1.00	1.20	1.29
2,640 lin.ft.	8–10	1.10	1.40	1.47
15-in.				
500 lin.ft.	0– 6	1.38	1.48	1.80
1,240 lin.ft.	6– 8	1.43	1.60	1.92
1,800 lin.ft.	8–10	1.53	1.75	2.05
910 lin.ft.	10–12	1.63	2.10	2.75
415 lin.ft.	12–14	1.73	2.30	3.00
3,500 lin.ft.	14–16	1.88	4.00	3.35
900 lin.ft.	16–18	2.03	6.25	3.94
525 lin.ft.	18–20	2.45	6.75	3.94
50 lin.ft.	20–22	2.68	10.90	5.31
Manholes				
12 Type A	0– 6	55.00	60.00	67.00
27 Type B	6– 8	65.00	70.00	69.00
21 Type B	8–10	77.00	82.00	83.00
12 Type B	10–12	89.00	96.00	98.00
11 Type B	12–14	103.00	110.00	118.00
2 Type B	14–16	113.00	125.00	128.00
3 Type B	16–18	125.00	150.00	164.00
1 Type B	18–20	137.00	175.00	179.00
17 cleanouts		12.00	14.00	24.00
72 lin.ft. 8-in. c. i. pipe		2.00	2.15	1.10
Totals		$39,768	$51,727	$53,214



LOW BIDS ON 6- TO 15-IN. V.C. PIPE AT 6- TO 22-FT. DEPTHS, DALLAS